CLASSIFICATION OF THE CALIFORNIA DESERT FOR GEOLOGY-ENERGY-MINERAL RESOURCE POTENTIAL

EXPERT PANEL CLASSIFICATION

Submitted to:

United States Department of the Interior
Bureau of Land Management
California Desert Planning Project

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DISCLAIMER

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ABSTRACT

Five mineral resource potential maps of the California Desert Conservation Area (CDCA) were prepared. One map was prepared for each of the following mineral categories: nationally important industrial minerals, regionally important industrial minerals, uranium, salines and metals. A map indicating sand and gravel pits was also prepared. A panel of ten geoscientists with extensive experience in mineral resource exploration and development and specific experience in the California desert prepared the maps. The maps were prepared for the U.S. Bureau of Land Management (BLM), Desert Plan Staff, as part of the development of a multiple-use plan of the CDCA. Geology-Energy-Mineral (G-E-M) Resources are one component of the multiple-use plan. The purpose of the maps is to assist in the development of land-use plans, not to guide mineral exploration.

The maps and accompanying report will be used along with many other sources of information in developing the G-E-M component of the plan. The Panel Moderator was Dr. John W. Harbaugh of Stanford University. Panelists were Dr. John P. Albers, U.S. Geological Survey; Dr. John T. Awald, Systems Exploration, Inc.; Dr. Kenneth C. Bullock, Brigham Young University; Dr. James F. Davis, California State Geologist; Dr. Frederic G. Files, U.S. Department of Energy; Cliffton H. Gray, Jr., California Divison of Mines and Geology; Paul K. Morton, California Division of Mines and Geology; Dr. Gordon B. Oakeshott, Consulting Geologist; Dr. Charles F. Park, Jr., Stanford University; and Dr. Ward C. Smith, Stanford University. TERRADATA provided each panelist with an extensive folio of maps, data and reports which included all relevant information available to the G-E-M Resources Group of BLM's Desert Plan Staff. The panel held an initial one-day meeting followed by individual efforts. The final classifications were developed at a three-day meeting. The panel divided its work into four committees based on categories of minerals. These were metals, uranium and thorium, industrial minerals and salines. Committee assignments were based on individual expertise. Four land classification categories are indicated on the maps. Though the specific definitions vary from map to map, mineral potential is indicated as favorable, intermediate, unfavorable or insufficient information to classify. Accompanying each map is a committee report on how the classification was accomplished and individual panelists' comments regarding the classification.

The classification maps represent the best collective judgment of the panel in light of incomplete data and incomplete assumptions regarding the future economic value of specific minerals and technological change. Since completely accurate forecasts of these important factors are impossible, the resultant maps should be regarded as "the best current estimate" rather than a "prediction of the future."

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1. INTRODUCTION

1.1 BACKGROUND

In 1976, the U.S. Congress revised the federal laws under which the Bureau of Land Management (BLM) operates with the passage of the Federal Land Policy and Management Act (FLPMA; PL 94-579). A part of this new legislation directs BLM to develop multiple-land-use plans and management programs for lands under its jurisdiction.

The diversity of resources, both economic and aesthetic, of the California desert plus its proximity to metropolitan Los Angeles creates a multitude of land use pressures which often conflict. For this reason, Congress, in FLPMA, designated the California Desert Conservation Area (CDCA) to be the prototype region for BLM planning and management efforts. The CDCA comprises about 107,000 square kilometers (25 million acres) in southeast California (see Figure 1).

The BLM planning effort consists of two phases:

- Preparation of an inventory of the resources of the CDCA to generate a multiple-resource data base. Botanical, soil-water-air, recreation, economic, wildlife, cultural and Geology-Energy-Mineral (G-E-M) resource inventories are being conducted.

- Formulation of a recommended land use plan providing for resource conservation, use and development by September 30, 1980. The recommended plan is to be submitted to the U.S. Congress.

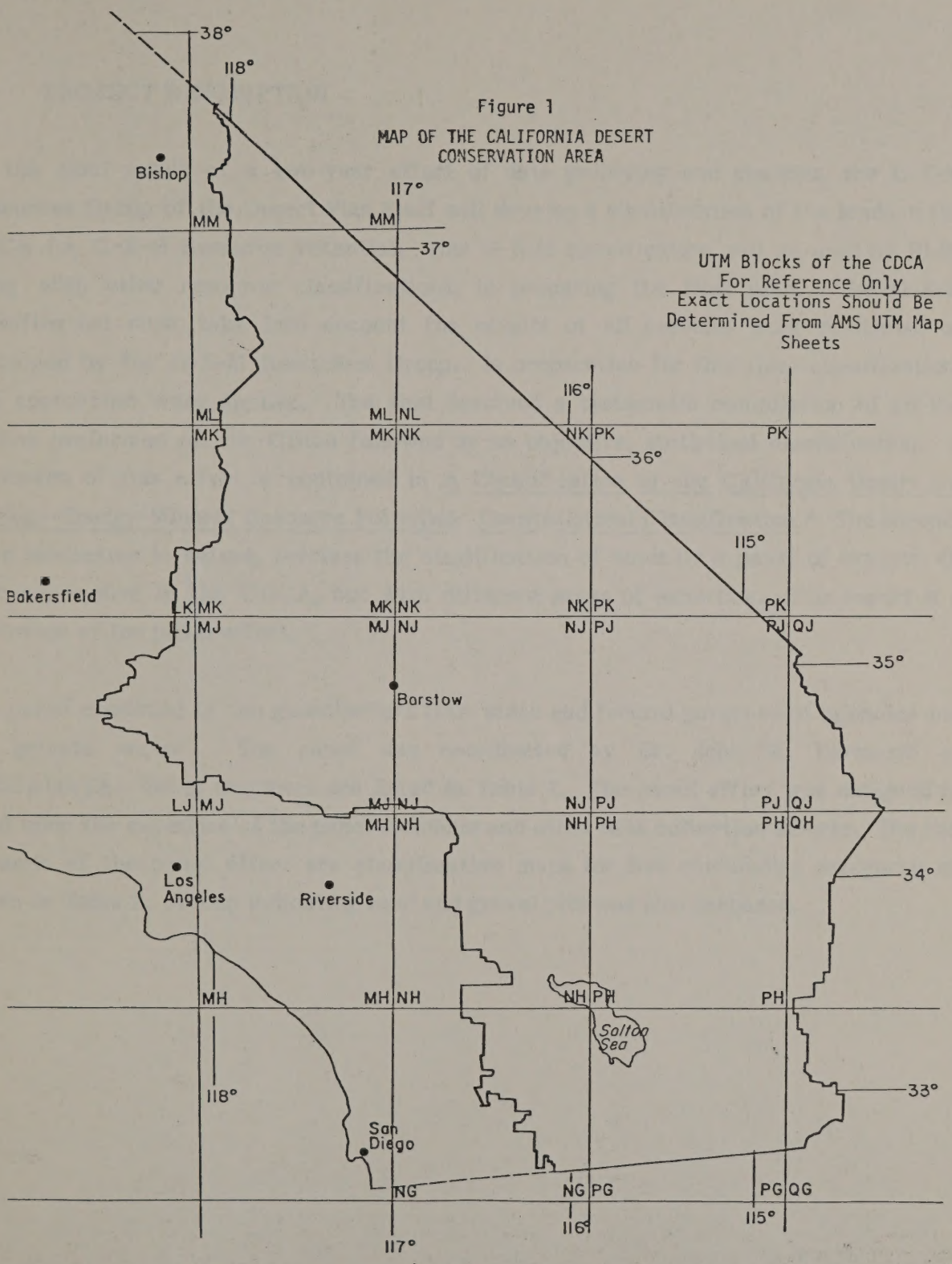

Figure 1

MAP OF THE CALIFORNIA DESERT
CONSERVATION AREA

1.2 PROJECT DESCRIPTION

As the final result of a two-year effort of data gathering and analysis, the G-E-M Resources Group of the Desert Plan Staff will develop a classification of the lands in the CDCA for G-E-M Resource Potential. This G-E-M classification will be used by BLM, along with other resource classifications, in preparing the final plan. The G-E-M classification must take into account the results of all previous work conducted or sponsored by the G-E-M Resources Group. In preparation for this final classification, two approaches were applied. The first involved a systematic compilation of all the studies performed on the CDCA followed by an objective, statistical classification. A discussion of this effort is contained in A Classification of the California Desert for Geology-Energy-Mineral Resource Potential: Geostatistical Classification.* The second, more subjective in nature, involves the classification of lands by a panel of experts, all with experience in the CDCA, but with different areas of expertise. This report is a discussion of the panel effort.

The panel consisted of ten geoscientists from state and federal government agencies and the private sector. The panel was coordinated by Dr. John W. Harbaugh of TERRADATA. Panel members are listed in Table 1. The panel effort was designed to build upon the expertise of the panel members and other data collection efforts. The end products of the panel effort are classification maps for five commodity categories as shown in Table 2. A map indicating sand and gravel pits was also prepared.

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*TERRADATA, July 1979

Table 1
PANEL MEMBERS

	Committee Assignments
Federal Government	
John P. Albers U.S. Geological Survey Menlo Park, California	Salines Uranium
Frederic G. Files Department of Energy Reno, Nevada	Metals Uranium
California State Government	
James F. Davis State Geologist and Chief California Division of Mines and Geology Department of Conservation Sacramento, California	Industrial Minerals Salines
Cliffton H. Gray, Jr. California Division of Mines and Geology Sacramento, California	Industrial Minerals Salines
Paul K. Morton California Division of Mines and Geology Santa Ana, California	Industrial Minerals Salines
Private Sector	
John T. Awald Systems Exploration, Inc. Denver, Colorado	Metals Uranium
Kenneth C. Bullock Brigham Young University Provo, Utah	Metals Uranium
Gordon B. Oakeshott Oakland, California	Industrial Minerals Salines
Charles F. Park, Jr. Department of Applied Earth Sciences Stanford University Stanford, California	Metals Industrial Minerals
Ward C. Smith Department of Applied Earth Sciences Stanford University Stanford, California	Industrial Minerals Salines
Panel Coordinator	
Professor John W. Harbaugh Stanford Univeristy Stanford, California	
TERRADATA Staff	
Frederic W. Lambie, Project Manager Glen R. Kendall, Project Director Antonia Stanaitis	

TABLE 2

COMMODITY CATEGORIES

Metals	Nationally Important Industrial Minerals	Regionally Important Industrial Minerals
Antimony	Asbestos	Abrasives
Copper	Special Clays	Diatomite
Gold	High Quality Silica	Feldspar
Iron	Talc	Gemstones
Lead	Wollastonite	Kyanite-sillimanite-andalusite
Manganese	Zeolite	Limestone and Dolomite
Mercury		Magnesite
Nickel		Mica
Molybdenum		Perlite
Rare Earths		Pumice
Silver		Pyrophyllite
Tin		Specialty Sands
Titanium		Sulfur
Tungsten		
Vanadium		

Salines	Uranium	Sand and Gravel
Borates		
Calcium chloride		
Gypsum		
Lithium		
Magnesium salts		
Potassium salts		
Salt		
Sodium carbonate		
Sodium sulfate		
Strontium		

1.3 SUMMARY

The panel prepared five classification maps at scale 1:250,000 as follows:

- Nationally Important Industrial Minerals
- Regionally Important Industrial Minerals
- Combined Metals
- Saline Minerals
- Uranium

Each map is accompanied by a report describing the classification process, the classification categories and comments on the results. These are contained in Section 3 of this report.

While the specific definitions of the classification categories vary from map to map, in general, four classification categories were used. They are:

1. Favorable
2. Intermediate
3. Unfavorable
4. Insufficient Information

A favorable rating does not imply a mineral deposit is likely to be found in an area, only that one is more likely to be found than in an area classified as intermediate. Similarly, a find is more likely in an intermediate area than in one with an unfavorable rating.

The classifications apply to large tracts of land (from ten square kilometers to thousands of square kilometers); therefore, a wide range of geologic environments may be present and mineral potential could vary greatly within lands classified in the same favorability category. Furthermore, the demarcation of classification boundaries is approximate, reflecting the accuracy of the information used (e.g., 1:250,000 geologic maps) and the uncertainty of rock types overlaid by recent geologic activity.

In developing the classification maps, the panel addressed several very difficult philosophical or methodological issues. Some of these were resolved by explicit assumptions, others by subjective consideration. Some of these issues are listed below.

1. While the available data were the best available, there were obvious shortcomings and deficiencies.

2. Some minerals which cannot be extracted from the CDCA economically today may be economically attractive in the future. These include those for which there is currently a cheap foreign source and those with no apparent economic use at present. This issue was addressed subjectively by each panelist.

3. Conversely, some minerals that are important today may not be important in the future. These include minerals that may be replaced by cheaper synthetics and minerals used for purposes that are not long-term.

4. For some resources considered by BLM (including most G-E-M resources) a planning horizon of 25 years may be sufficient for development, but for other resources (most notably wilderness areas) a much longer period is implied. Therefore, the panel attempted to estimate mineral potential with a horizon of 100 years.

5. The interpersonal communication among panelists is important. A group consensus may not represent the "best collective judgment."

Despite these reservations, the maps should be useful to BLM planners. A great deal of concentrated effort went into their preparation. They summarize a wealth of data, information and personal knowledge.

2. THE PANEL CLASSIFICATION PROCESS

2.1 PROJECT APPROACH

There were three main steps in the panel classification process: an initial briefing, individual classification efforts culminating in the preparation of individual classification maps and a final panel meeting.

The initial briefing provided an opportunity for the panelists to meet one another and exchange ideas. All data available to the panelists from TERRADATA and BLM were presented and discussed. The panelists selected the information, data and maps they desired to supplement their own knowledge for their classification efforts.

Four committees were formed, one responsible for each commodity category (the two industrial mineral categories and sand and gravel were treated by the same committee). Each panel member served on two committees according to his expertise. The committee assignments are indicated in Table 1.

Shortly after the initial briefing each panelist prepared a classification map of two sample areas for each committee to which he was assigned. These preliminary classifications were distributed to other members of the appropriate committees for comparison. The sample areas, representing about ten percent of the CDCA, had been selected by each committee during the initial panel briefing so consistent comparisons could be made.

After the sample area classification maps were distributed a telephone conference call for each committee was held. During the call, the committee members discussed techniques used for classification, inconsistencies, definitions of classification categories and other problems. This mid-course check insured that the individual classification maps were formed on a consistent basis. Several of the panelists had individual telephone conversations as well. Following the conference calls each panelist made whatever adjustments were necessary and completed his two classification maps in preparation for the final panel meeting.

The final panel meeting was held June 12 to June 14, 1979. During that meeting each committee met to compare and discuss the individual classification maps and to develop one final committee classification map (two in the case of industrial minerals). These maps were then reviewed by the entire panel. Each committee produced a report containing a short description of the classification process used by that committee. In addition to the committee report, members of each committee submitted individual comments on the adequacy of the data, applicability of the maps and reservations concerning any aspects of the effort. These committee reports and individual comments are contained in the last section of this report. The overall panel classification process is illustrated in Figure 2.

2.2 SOURCES OF INFORMATION

TERRADATA provided each panelist with a folio of maps, information and data compiled from public and BLM sources. Panelists supplemented the folio with additional information in a few cases. The folio consisted of the following:

— Geologic Maps of California -

Maps published by the California Division of Mines and Geology (CDMG) for 12 quadrangle sheets at scale 1:250,000 covering the entire CDCA; and in one sheet for all of California at scale 1:750,000. (The quadrangles are Mariposa, Death Valley, Bakersfield, Trona, Kingman, Los Angeles, San Bernardino, Needles, Santa Ana, Salton Sea, San Diego and El Centro.)

— Topographic Maps -

Maps distributed by the U.S. Geological Survey (USGS) at 1:250,000 scale for the same 12 quadrangles as the geologic maps.

— Mineral Occurrence Maps -

Maps, compiled by TERRADATA, include all reported mineral deposits in the CDCA. The five maps at 1:250,000 and 1:500,000 scales are:

All Reported Occurrences

Reported Metal Occurrences

Locations of Preliminary Reconnaissance Reports on Uranium

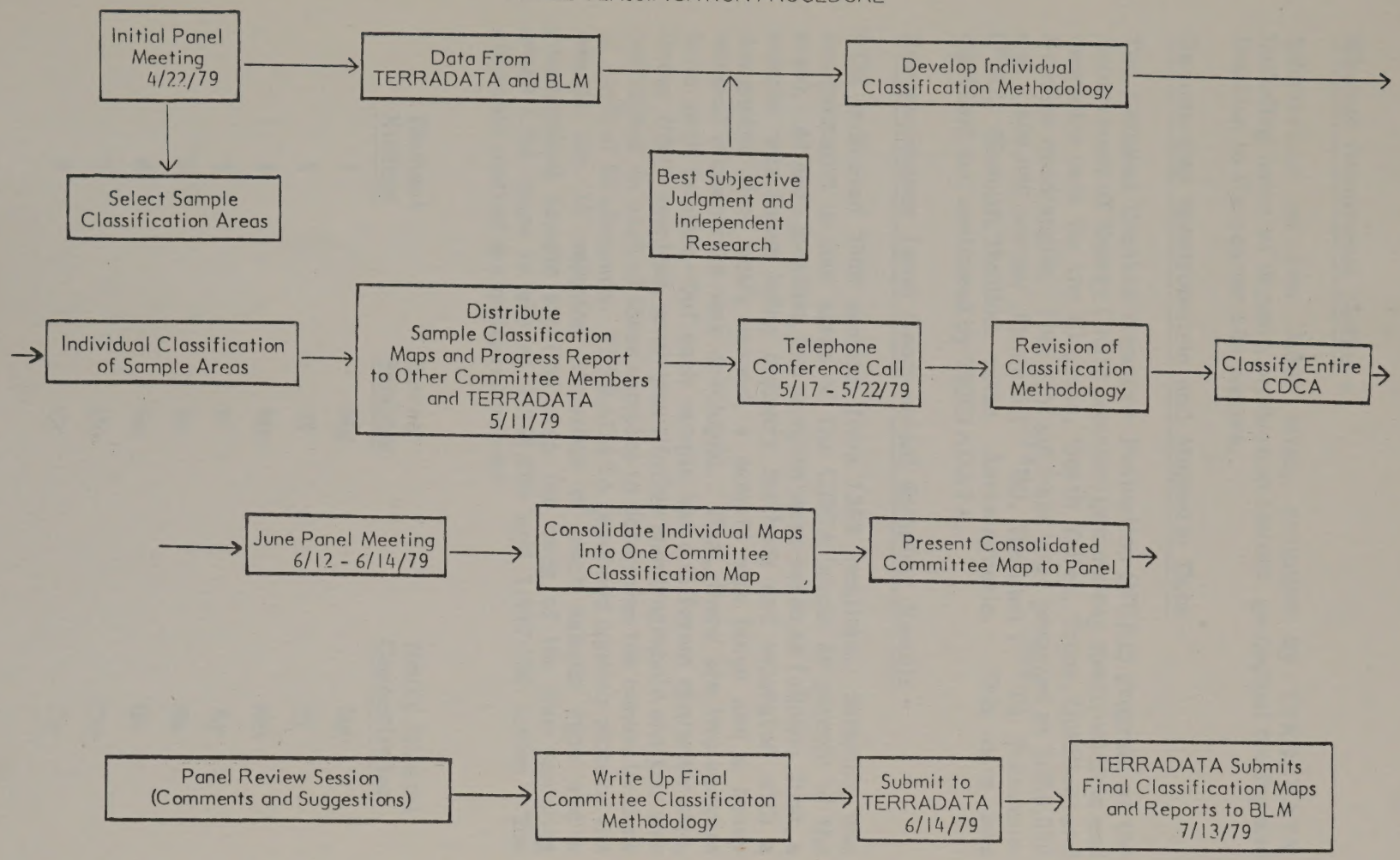
Reported Industrial Mineral Occurrences

Reported Saline Occurrences

Figure 2

FLOW CHART

PANEL CLASSIFICATION PROCEDURE



— Mineral Occurrence Listing -

Information on over 3,000 sites, compiled by TERRADATA, including name of deposit, production history, geological setting and location to the nearest 500 meters.

— Gamma-Ray Spectrometric and Magnetic Data -

The National Uranium Resource Evaluation (NURE) program of the Department of Energy (DOE) provided gamma-ray spectrometric and magnetic data for the Kingman, Death Valley, Trona, Goldfield and Needles quadrangles. Five contour maps were prepared at 1:250,000 and 1:500,000 scales: Bismuth (^{214}Bi), Thallium (^{208}Tl), Potassium (^{40}K), Bismuth/Thallium ratio, Aeromagnetic. This data was digitized and contoured by TERRADATA.

— Reconnaissance Level Geochemical Sampling Results -

BLM collected 2500 samples from 1250 locations. Sampling was concentrated in four areas of the CDCA (about 50 percent of the area). At each location, two samples were taken as follows: first, a sample was taken using ordinary methods and separated with a designated size mesh; second, a sample was taken and a heavy mineral concentrate was developed. Thus, there are two samples from each location—but each sample has a different characteristic. Under USGS auspices, semi-quantitative spectrographic analysis was performed on each of these samples to determine the concentrations of each of 65 elements. TERRADATA produced contour plots of the results for 15 selected elements of each sample type and a geochemical sample location map for each of the four sampling areas (124 maps in all) at 1:250,000 and 1:500,000 scales. The elements plotted are indicated below:

Element Number	Sieved Samples	Heavy Mineral Concentrates
1	Mg	Mg
2	Ti	Ti
3	Mn	Mn
4	B	Ag
5	Ba	Ba
6	Be	Be
7	Co	Co
8	Cr	Cr

9	Cu	Cu
10	Mo	Mo
11	Nb	Pb
12	Pb	Sn
13	V	Zn
14	Zn	K
15	Ce	Ce

— Gravity Map -

Contour map of Bouguer gravity anomalies for the entire CDCA as compiled by Dr. Shawn Biehler of U.C. Riverside at 1:250,000 and 1:500,000 scales.

— Lineaments -

Maps of lineaments as interpreted from LANDSAT, gravity contours, Skylab and aerial photographs by General Electric (GE) under contract to BLM for the entire CDCA at 1:250,000 and 1:500,000 scales. More detailed maps of three 80-kilometer by 80-kilometer subareas, also by GE, at 1:100,000 scale.

— Classification Map for Salines -

Map, prepared by the USGS, classifies the CDCA for sodium and potassium salts potential, at 1:500,000 scale.

— Lithologic, Geophysical and Water Quality Data -

Plats, prepared by the USGS, showing Gamma, Gamma-Gamma, Neutron, Lithologic and Water Quality well-log analyses for 27 test wells. The wells were drilled in:

Ford Dry Lake

Cuddleback Dry Lake (2 wells)

Cadiz Dry Lake

Coyote Dry Lake (2 wells)

Ivanpah Valley

Broadwell Dry Lake

Superior Dry Lake

Danby Dry Lake (2 wells)

Bristol Dry Lake (2 wells)

Palen Dry Lake (2 wells)

Means Dry Lake

Eureka Valley Dry Lake

Soda Dry Lake

Dale Dry Lake

Franklin Dry Lake

Soggy Dry Lake

Clark Lake

Lucerne Dry Lake

El Mirage Dry Lake

Melville Dry Lake

Emerson Dry Lake (2 wells)

— Tonal Anomalies -

Maps, prepared by GE under contract to BLM, show visually interpreted tonal anomalies from enhanced LANDSAT imagery for three 80-kilometer by 80-kilometer areas at scale 1:100,000.

— Reconnaissance Field Data Verification Studies -

Studies conducted by BLM cover approximately ten percent of the CDCA. They include information on the geology, physiography, structure, mining history and known deposits and a classification according to mineral potential for certain areas. Draft reports cover the following areas:

Central Argus Range

Panamint Mountains

Chuckwalla Mountains

Ord Mountain

Sidewinder Mountain

Stoddard Ridge

Oro Grande Area

Shadow Mountains

— A Geostatistical Study and Classification for G-E-M Resources in the California Desert -

Study, conducted by TERRADATA, includes a compilation of all known G-E-M occurrences in the CDCA plus geostatistical classification maps for potential of the following at 1:250,000 and 1:500,000 scales:

— gold
— combined lead, silver, copper, zinc
— iron
— manganese
— tungsten

— Demographic and Economic Trends in the California Desert, Future Demographic and Economic Trends in the California Desert and Future Technology in the California Desert -

Reports prepared by SRI International under contract to BLM.

— Initial Wilderness Inventory for Public Lands Administered by the Bureau of Land Management -

Report and Map prepared by the California State Office of BLM.

2.3 CLASSIFICATION CATEGORIES

The purpose of each classification map is to depict the potential of the CDCA for a specific group of minerals. Each map was the responsibility of a particular committee. Each committee acted independently, subject only to some general guidelines.

Among these guidelines were general specifications for the classification categories to be used on the maps. Initially three categories were suggested: "favorable," "intermediate" and "unfavorable." At the suggestion of the panelists, a fourth category, "insufficient information to classify," was added. Interpretation of these categories varied greatly, not only from committee to committee, but also among individuals of the same committee. Thus, several related but distinct classification schemes were employed by each panelist to prepare the individual maps.

Each committee resolved variations in these classifications to produce a single map with consistent definitions. However, differences still exist in the definitions of classification categories from committee to committee. The categories derived by each committee and their definitions are outlined in Table 3. More detailed descriptions of these definitions are given in the last section of this report. It should be emphasized that these categories are not interchangeable between classification maps. For example, the Metals Committee considered the criteria of production history to be important enough to warrant a special category of "very favorable" for areas that have reported production exceeding $500,000.

Table 3

CLASSIFICATION CATEGORY DEFINITIONS

	Category Definition			
Category	Industrial Minerals Classification Map	Metals Classification Map	Salines Classification Map	Uranium Classification Map
1A		very favorable areas		
1	information indicates resource present or likely to be present	favorable areas	information indicates resource present or likely to be present	favorable areas
2	information indicates resource could be present	intermediate areas	information indicates resource could be present	intermediate areas
3	information indicates resource unlikely to be present	unfavorable areas or insufficient data	information indicates resource unlikely to be present	unfavorable areas
4	insufficient information		insufficient information	insufficient information

Industrial minerals were divided into three categories:

- Critical Industrial Minerals - Industrial Minerals of National Importance
- Industrial Minerals of Regional or Statewide Importance
- Construction Materials

Separate classification maps were prepared for industrial minerals of regional and of national importance. Construction materials are abundant in the CDCA and their value is very sensitive to their relative location to site-specific needs such as transportation facilities or construction sites. Thus, the panel provided no resource classification map for construction materials, since much of the CDCA is potentially favorable. However, the panel considered sand and gravel to be of sufficient economic importance to produce a map showing reported sand and gravel pits.

2.4. COMMITTEE CLASSIFICATION PROCESS

Committee efforts were conducted in two main steps. The first was to compare all individual maps with regard to the classification areas, classification technique and the classification categories used to identify differences in definitions and methodology. The second centered on resolution of the differences. The actual drafting of the maps followed easily with only minor site-specific modifications based on an individual's knowledge of that area. Thus, the final map frequently represented a compromise between committee members. This is discussed in detail in the last section, Committee Reports.

The general procedure of compilation was as follows:

1. Compare all individual maps
2. Discuss differences
3. Develop consensus classification categories
4. Translate individual classification categories into consensus classification categories
5. Perform classifications
6. Prepare report on rationale of classification
7. Prepare individual comments

3. COMMITTEE REPORTS

This section contains the reports of the four committees of the panel regarding classification methodology and classification categories. Comments by individual committee members regarding the quality of the data and other factors are also presented.

3.1 SALINE MINERALS

Committee Members: Gordon Oakeshott, Ward Smith, John Albers, James Davis, Paul Morton, Cliffton Gray.

The saline minerals group includes the borates, calcium chloride, gypsum, magnesium salts, potassium salts, salt, sodium carbonate, sodium sulfate, strontium, lithium and others.

The committee used four categories of classification, defined as follows:

1. Available information indicates that a saline resource is present or likely to be present.
2. Available information indicates that a saline resource could be present.
3. Available information indicates that a saline resource is unlikely to be present.
4. Available information is insufficient to enable judgment as to whether a saline resource is present or not.

The committee members generally agreed on methodology and on the application of that methodology; therefore, one map was selected for detailed examination and revision. After discussion of those areas known or deemed to have resource potential, the boundaries of areas classed in Categories 1 and 2 were refined on that map.

Areas classified into Category 1 were largely restricted to areas having known productive resources, areas where test-well data show saline layers present and, in some cases, to restricted topographic depressions between fairly closely spaced wells showing saline content. The Salton, Brawley and other Known Geothermal Resource Areas are included in Category 1 because the fluids are saline and may yield recoverable saline resources if geothermal energy is exploited.

Most Category 2 areas are in basins which surround the boundaries of Category 1 areas. They indicate possible extensions of known resources. Category 2 was also used in a few other areas where lithology is considered favorable for some types of saline deposits, such as gypsum.

Category 3 was applied mainly to the many areas of such rocks as granite, volcanic and metamorphic rocks, where the occurrence of salines is highly unlikely. Category 4 was applied mainly to basin and alluvial areas where there has been no drilling or insufficient drilling to characterize the subsurface. The relatively large amount of area classed in Category 4 is an indication of the overall poor quality and inadequate coverage of the data in the large percentage of area covered by the basins. The quality of data in these basins can be improved significantly only by a substantial amount of deep drilling.

Ward Smith Comments:

The individual saline maps brought in by panel members were in rather good agreement. This reflects the limited number of closely related commodities considered (gypsum in older rocks excepted). The general procedure was good, considering the restraints on time.

To prepare an improved map would require more data from basin test holes.

Gordon Oakeshott Comments:

The term saline minerals in our classification includes evaporites and minerals from saline sources. Borates, and other minerals in desert lakes and playas—including tungsten and other metallic salts, zeolites, clays and even sand—are close associates of the true salines. Thus, there is overlap with the industrial minerals. The uses of borates, gypsum and many other "salines" are very largely industrial uses.

Salines and associated mineral substances will come mostly from sea water by the end of this century. The Salton Sea (and other lakes) may not share in this development because of political decisions to maintain constant shorelines. Future uses of many areas for mineral resources depend on what man decides to do regarding environmental and political actions. For example, will we allow evaporation of some of the waters of the Salton Sea? Present trends (Salton Sea and Lake Elsinore) seem to be toward maintaining the water levels so that the shorelines do not change. In other instances (Owens Lake and Mono Lake), water levels are being lowered by utilization of their sources of water. Mineral rights on Owens Lake are being preserved and enhanced. Mono Lake may develop economic evaporites. What man may decide to do in the next many years is difficult, if not impossible, to judge.

With respect to the classification map, a few areas are unclassified (no category numbers used), like the Mariposa sheet. Category 1 (Favorable) is used extremely sparingly. "Favorable," to me, means the likelihood or probability of occurrence of certain minerals of present, or future, value. Use of Category 1 has been too restricted.

Category 4 is used too widely; by exercising some subjective judgment, we could do better than this.

In a number of places, the area of a given category is too small to be significant in the land-use classification.

All desert lakes and playas (all areas within depression contours) should be included in Category 1 (if productive) or Category 2, because if not the salines themselves, other saline-associated mineral resources are likely to be present. They nearly all contain clays in their upper (Holocene) beds, for example.

3.2 URANIUM COMMITTEE REPORT

Committee Members: Frederic Files, Kenneth Bullock, John Awald and John Albers

All committee members prepared individual classification maps for the entire area. The main data sources used were:

- 1:250,000 Geologic Map Sheets published by the CDMG.
- Reported Uranium occurrence information provided by TERRADATA.
- Geophysical, Lithologic and Water Quality Data, prepared by the USGS for 27 test wells, an Open File Report.
- Gamma-ray spectrometric data for Bismuth, Thallium, Potassium and Bismuth to Thallium ratio for the northern half of the CDCA only.

The radiometric data showed wide variation from one quadrangle to another and were, therefore, used with caution.

There was excellent agreement among the panelists' individual maps in almost all bedrock areas, but there was some disagreement over the classification of the alluvial valleys. The disagreement centered on the interpretation of the uranium concentrations in the test-well data. Several wells showed unusually high concentrations of uranium. These might indicate potential if it becomes feasible to extract uranium from well brines. On the other hand, low concentrations might indicate a trap for uranium somewhere between the well and the many uranium source rocks surrounding the valleys.

Thus, most of the efforts of the committee were spent deciding how to classify the basin areas. The final classification category definitions are shown below:

1. Favorable

   — Tertiary and Quaternary intermediate and silicic volcanic rocks

   — Tertiary intermediate and silicic intrusive rocks

   — Precambrian rocks where uranium occurrences are present (otherwise classified intermediate)

   — Mesozoic granites containing known occurrences (otherwise classified intermediate)

   — Local rock units with known uranium occurrences.

   — Areas of influence around test wells indicating greater than 20 parts per billion (ppb) uranium (see note below)

2. Intermediate

   — All Mesozoic granitoids without known uranium occurrences which may contain local (vein-type) deposits

   — Precambrian granitic-metamorphic complex not containing known occurrences

   — Pre-Cretaceous/Metasedimentary rocks (excluding Paleozoic sediments)

   — Tertiary granitic rocks on the Death Valley 1:250,000 quadrangle sheet

3. Unfavorable

   — Paleozoic and Mesozoic sedimentary and metavolcanic rocks

   — Basalts of Tertiary and Quaternary ages

   — Areas of influence around test wells indicating less than 20 ppb uranium (see note below).

4. Insufficient information to classify

   — All basins not drilled, all basin regions outside the area of influence of well-log data and all regions below the depth of test wells (see note below).

NOTE: Waters in 6 out of 27 test wells drilled by the USGS[1] in a number of the basins contained more than 20 ppb uranium, which was considered to be anomalously high. Each of these holes was given an "area of influence" ten miles in diameter, shown by dashed circles on the map. These areas of influence are given a favorable (1) rating. The remaining holes whose waters contain less than 20 ppb uranium are also circled with a ten-mile diameter, shown by a dotted line. These latter circled areas are given an unfavorable (3) rating (but only to the depth tested). The remaining basins in the CDCA where no test wells are present are considered to have insufficient information to classify (4).

Data on thorium favorability were almost completely lacking, but available indications are that there is little or no favorability for thorium in the CDCA.

Frederic Files Comments:

It was the consensus of the panel, I believe, that the available data were quite inadequate for a thorough classification of the Uranium/Thorium favorability of the CDCA. I found the USGS data from wells drilled in several of the basins particularly useful, as it was the only information about this extensive and potentially favorable environment available.

It is my belief that several of the basins we have placed in the category insufficient information to classify (4) may be favorable (1). To my thinking, closed basins with an abundance of identifiably uraniferous "source rocks" in their drainage could present a number of attractive drilling targets, perhaps the best exploration targets for uranium in the CDCA. We have identified well locations which yielded water samples containing more than 20 ppb as favorable, but many basins with surrounding "source rocks" have no drill-hole data, and those which do generally have only one or two holes (inadequate to test such a large area), usually located somewhere within the central playa, not necessarily the best location to gain information on uranium favorability, and seldom bottomed in bed rock. The Panamint Valley, for which we had no drill hole data, presents a good example of my thesis. It has large areas of uraniferous "source rocks" in its drainage, including alkali-rich intrusive rocks of the Hunter Mountain batholith at the north end of the valley and uraniferous Precambrian rocks of the World Beater complex and Lime Kiln Spring Formation on the east side. A possible bedrock high separating the northern and southern halves of the valley is apparent from the Bouguer gravity data. Thus, it is possible that a situation exists where uraniferous ground waters could have been forced upward over this basement high in much the fashion thought to have been important in formation of the uraniferous calcrete deposits at Yeelirrie. The known anomalous water sample obtained from the Lucerne Valley drill hole makes the possibility of potentially economic uraniferous brines worth serious consideration. Also, the known presence of abundant organic material in the sediments of some of the basins may create

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[1]U.S. Geological Survey. Geophysical, Lithologic and Water Quality Data from Test Wells in the California Desert. Open File Report. 1979.

conditions favorable for the formation of roll-type uranium deposits in some cases. Any of these targets might exist in Panamint Valley.

The panel was forced to agree upon what we considered to be a geologically defensible rationale for classification because of the paucity of data. I see the need for this approach, but consider it rather unimaginative and doubt that many explorationists would like to be bound by it.

Kenneth Bullock Comments:

1. Favorable uranium occurrences were determined from areas of reported occurrences and productive mines. Radiometric anomolies were helpful in areas having airborne coverage. Six drill sites in the valleys have underground waters with more than 20 ppb uranium. Geologic rocks considered favorable are given in the committee's summary. More complete airborne data would have been helpful.

2. Intermediate areas represent less confidence in geologic units and low radiometric readings.

3. Unfavorable areas are generally Paleozoic sediments and drilled valley areas where uranium readings are less than 20 ppb.

4. Insufficient information areas are undrilled valleys throughout the CDCA. Drilling to bedrock would be desirable in future projects, to determine any economic potential of the valleys.

John Awald Comments:

I was disappointed in the quality of the DOE radiometric survey data. Only the northern portion of that data was used. There appeared to be significant differences in the calibration or sensitivity levels between the northern and central portions of the survey area such that the latter had a "background" level as high as the anomalies in the northern portion. I am, however, highly satisfied with geologic classifications made.

It is without special merit to comment adversely on the uranium data other than to note the problem with the radiometric data cited.

In my company's survey work of the southwestern United States, we see special exploration problems resulting from the leaching of source rocks and sediments derived therefrom by the same weathering conditions (and including secondary saline (alkaline) waters) that has resulted in the formation of secondarily enriched porphyry copper "blankets." The result is that surface evidence of uranium is apparently subdued by leaching removal to a greater extent than in the northern states. In southern California, special attention has to be given to geochemical measurements of uranium in the hydromorphic cycle. Clearly, from the evidence in hand, there is more than adequate uranium available for the formation of economically valuable deposits. To find these in the sedimentary basins where they are more likely to occur will require sampling and analytical practices that are improvements of those now in practice and drill testing of results from these methods.

In view of the time constraints imposed on the panel and the divergence of approaches used to classify essentially the same data, the extent of correlative agreement in preparation of the uranium map was impressive. I am comfortable with the results.

3.3 METALS

Committee Members: Charles Park, Kenneth Bullock, John Awald and Frederic Files.

Metals are defined to include all metallic elements except uranium and thorium. Historically metals deposits in the CDCA have been dominated by gold, lead, silver, copper, zinc, iron, manganese and tungsten. Less mining activity has occurred for antimony, nickel, mercury, molybdenum, vanadium, titanium, tin and the rare earths. Nevertheless there are some large and important mines associated with this second class of elements.

The primary sources of data used for the classification were:

- 1:250,000 Geologic Map Sheets published by the CDMG.
- Map showing Mineral Exploration Potential, Death Valley Quadrangle, 1:250,000, by Roscoe Smith, USGS, 1977.
- Map showing reported metal occurrences prepared by TERRADATA.
- Contour maps of geochemical sampling prepared by TERRADATA from data provided by BLM.
- Discriminant function classification maps for gold; copper, lead, silver, zinc combined; iron; manganese; and tungsten, prepared by TERRADATA.
- Personal knowledge of the panelists.

Each panelist prepared an individual map classifying areas into one of three relative categories: favorable, unfavorable and intermediate. Not all areas were classified by each panelist, however. Charles Park classified lands in the northern half of the CDCA down to a few miles south of Barstow. Kenneth Bullock classified the southern lands up to a few miles above Barstow. Frederic Files and John Awald classified the entire area. The panelists were guided by definitions for favorable, unfavorable and intermediate, but interpretations of these categories and approaches to classification varied. The

definitions applied by each panelist to their individual maps are described below:

Charles Park:

1. Favorable areas are defined by a limited areal extension according to the local geologic environment around deposits reported to have produced over $500,000.

2. Intermediate areas represent a more liberal areal extension according to the geologic environment around deposits reported to have produced between $50,000 and $500,000.

3. Unfavorable lands are all others.

Kenneth Bullock:

1. Favorable areas represent an areal extension according to the geologic environment around deposits reported to have produced over $50,000, or around indicated geochemical anomalies.

2. Intermediate areas are where an occurrence has been reported or production has been under $50,000, and where favorable geologic environments exist but no occurrences have been reported.

3. Unfavorable areas are all others.

John Awald:

1. Favorable areas include those that have:

   a. geochemical anomalies (greater than four standard deviations above the mean) coincident for three or more elements;

   b. discriminant function analysis results indicating greater than 75 percent probability of correct classification in the occurrence category coincident for three or more commodities; or

   c. a combination of any geochemical anomalies, any discriminant function analysis indicating potential, plus areas where deposits have been reported with production greater than $50,000 totalling three or more in number.

2. Intermediate areas include those that have:

   a. geochemical anomalies for any element,

   b. discriminant function analysis indicating potential for any commodity, or

c. reported occurrences of a mine or prospect.

Areas defined by 1 and 2 above were then extended approximately one mile according to the geology.

3. Unfavorable areas are all others.

Frederic Files:

1. Favorable areas were determined on the basis of the occurrence information emphasizing producers or coincidence of three or more discriminant function analysis results indicating potential. The 50 percent probability of correct classification line was used to indicate potential. These areas were then extended on the basis of geology.

2. Unfavorable areas were defined as those valley regions presumed to be underlaid by deep alluvium. The distances to bedrock were estimated using Bouguer gravity anomalies.

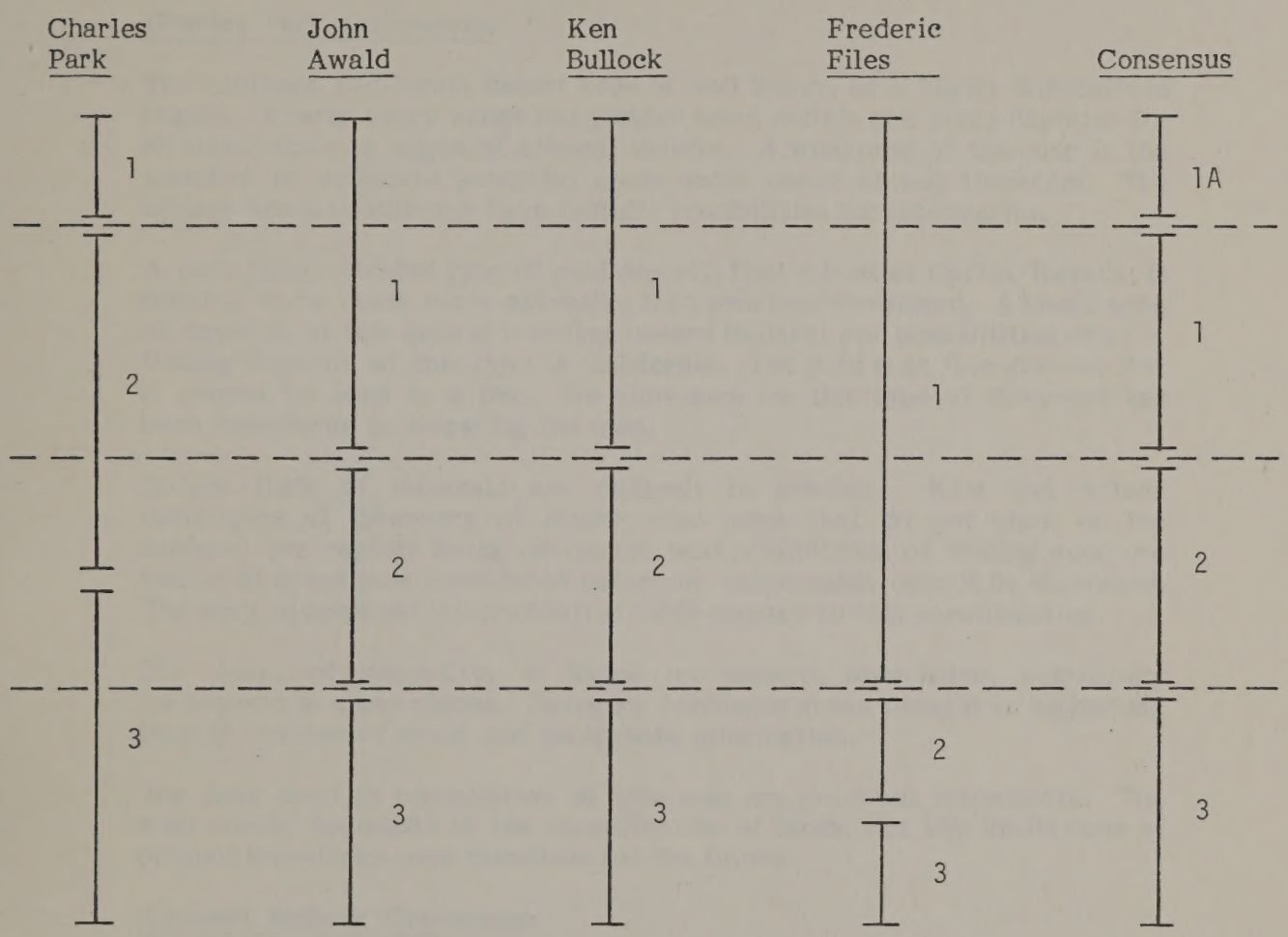
3. Intermediate areas are all others.

In general there was good agreement among the individually prepared maps. The main difference (indicated by the definitions above) is the division between the categories. Frederic Files' map had a limited extent of lands classified as unfavorable compared to the others, since he assigned shallow alluvial areas to the intermediate category. His divisions are, therefore, less restrictive than the others. On the other hand, Charles Park's divisions are more restrictive than the others. He assigned a very limited area to the favorable category and those regions assigned to the intermediate category compare with areas classified as favorable by the other panelists. The relative scale of classification categories is shown in Figure 3.

The composite map prepared from the four individual maps represents a compromise. First of all, areas assigned by Charles Park to the favorable category represent very favorable regions and are classified "1A." Some other areas were also classified "1A" on Kenneth Bullock's specific recommendation. Then all areas coincidentally classified by Frederic Files, John Awald and Charles Park in the north and by Frederic Files, John Awald and Kenneth Bullock in the south as favorable were classified "1." (Charles Park's intermediate category was considered favorable in this context.) Finally, the intermediate category was defined to include any other regions classified as favorable or intermediate on John Awald's, Charles Park's or Kenneth Bullock's map. This line corresponds closely to Frederic Files' definition of the intermediate category with a more restricted treatment of the shallow alluvial areas. It should be emphasized that the

Figure 3

Appraisal categories of the
four members of the Metals Committee



areas designated as "3" and referred to as "unfavorable" include both regions that are unfavorable and/or alluvial cover which may mask potentially economic metallic mineral resources. In other words, the categories "insufficient information" and "unfavorable" were combined on the metals map. Present data are insufficient to assess which of these alternative conditions are true.

Charles Park Comments:

The southern California desert area is well known as a highly mineralized region. Nearly every range has yielded some metals and many deposits are situated close to edges of alluvial valleys. A weakness of the map is the inability to delineate potential areas under cover of any thickness. The valleys beneath alluvium have definite possibilities for discoveries.

A very finely divided type of gold deposit, first mined at Carlin, Nevada, is proving to be much more extensive than previously realized. A broad zone of deposits of this type is trending toward Ballarat and possibilities exist of finding deposits of this type in California. The gold is so fine grained that it cannot be seen in a pan. No allowance for this type of discovery has been considered in preparing the map.

Future finds of minerals are difficult to predict. New and refined techniques of discovery of hidden ores (ores that do not show on the surface) are rapidly being developed, and possibilities of finding good ore bodies in areas now considered barren or unfavorable cannot be dismissed. The very widespread mineralization lends support to this consideration.

The map, of necessity, is based on present knowledge, admittedly inadequate in many places. Category 3 includes areas thought to be barren, largely because of cover and inadequate information.

The data used in compilation of this map are good but incomplete. The map should be useful in the classification of lands, but the limitations of present knowledge pose questions for the future.

Kenneth Bullock Comments:

1. Mineral occurrence and production data were very useful in localization of favorable metal areas. More current production from active mines would be helpful.

2. Geochemical data were helpful. I used the higher anomalies of various metals to help determine favorable areas. Grid sampling with greater density would be more definitive of such areas.

3. My "1A" classification in the southern half of the CDCA included three areas:

a. Vulcan iron property. (Sec. 25, T.10N., R.13E.) Production over 2 1/2 million tons by Kaiser. Drilled more recently by U.S. Steel. Large buried reserves. High sulfur.

b. Man-Ord deposits.

(1) Man property. (Sec. 4, T.6N., R.3E.) Buried deposit. Extensively drilled by U.S. Steel. Huge deposit.

(2) Ord property. (Sec. 3, 10, 11, T.6N. R.3E.) Buried deposit. Extensively drilled by U.S. Steel. Huge deposit, smaller than Man deposit.

c. Desert Eagle Property. (Sec. 31, 32, T.3S. R.15E.) Buried deposit east of Eagle Mountain deposits. Extensively drilled by U.S. Steel and Kaiser Steel. Huge deposit.

4. Intermediate areas have low production or only reported occurrences. Geologic environments are generally favorable for ores, which may be buried by alluvium in the valleys, or bedrock in the mountain regions.

5. Unfavorable areas generally are confined to the valley flats, basalt flows, or other low potential geologic environments.

6. Information and data were useful, but limited in many instances. I appreciate the problems and costs involved for such a large project.

7. Sources of data that have been helpful to me in some of my work include:

a. Names of active mines, including production figures, from U.S. Bureau of Mines. Some companies request that this data not be released to the public.

b. Names of operating and tax paying companies can be obtained from:

(1) State Tax Commission
(2) County Treasurer Offices
(3) State Land Offices - fee leases

8. Most of the deposits determined from sources in #7 are not published but give a current status of mining activity.

9. Computer contouring should be limited to areas bounded by sampling grid. Several distortions of anomolies were apparent in the current program.

Frederic Files Comments:

I have no particular comments on the quality of the data. However, I do feel the need to justify my more optimistic approach to the classification scheme somewhat. I was attempting to consider the possibilities over a 100-year time span which could make it possible to prospect even more effectively through relatively shallow alluvial cover. Thus, my area of "intermediate" favorability was somewhat larger than my fellow panel members. In the discussions of the panel, I was willing to compromise my definition.

John Awald Comments:

My concern for aspects of data preparation involve:

1. Many of the geochemical anomalies contoured at the three and four standard deviation level constituted "one location point" sites which burdens the precision and sample preparation accuracy of the emission spectrograph used especially with a material matrix that is as variable as these samples must be. There are, however, sufficient data to justify the expectation that follow-up field sampling and ground checking of the geology of multiple-sample anomalies could result in new mineral discovery. Such would go far to justify the underlying value of the analysis rendered by the panel. Since my company has been actively involved in exploration of much of the CDCA area over the past three years, the degree of correlation between the panel's data and "an independent source" encourages my confidence in the geochemical data prepared for the panel's use.

2. While I believe I understand the rational behind the use of discriminant function analysis, I remain somewhat skeptical that the assumptions guiding the selection of variables (particularly "number of fault intersections," "weighted number of LANDSAT lineaments which intersect," "sum of total length of LANDSAT lineaments passing through cell," and "cumulative length of lineaments passing through cell with azimuths between 352.5^{o} and 1.5^{o} East of North," see A Geostatistical Study in Geology-Energy-Mineral Resources for the California Desert, December, 1978) necessarily aided the classified distribution of certain commodities, specifically manganese, tungsten and gold. Nevertheless, these data were used.

3. In order to appreciate adequately the significance of contoured data, it is important to understand the decision criteria for drawing the contour lines. While I do not know these criteria, particularly concerning edge control, I assumed these were "adequate."

   In view of the time constraints imposed on the panel and the divergence of approaches used to classify essentially the same data, the extent of correlative agreement in preparation of the metals map was impressive. I am comfortable with the results. Beyond this, moreover, I would like to suggest that, if the areas designated by the panel as being of intermediate or favorable value for metals are preserved for development by the BLM, then the values of our effort will be proven by new economic mineral discovery within the next ten years.

3.4 INDUSTRIAL MINERALS

Committee Members: Charles Park, Gordon Oakeshott, Ward Smith, James Davis, Paul Morton, Cliffton Gray

The industrial minerals category contains a wide diversity of commodities, including the following:

Abrasives	Mica
Asbestos	Perlite
Barite	Pumice
Clay	Roofing Granules
Dimension Stone	Sand and Gravel
Diatomite	Silica
Feldspar	Specialty Sands
Fluorspar	Sulfur
Gemstones	Talc
Kyanite	Volcanic Cinders
Limestone	Wollastonite
Magnesite	Zeolites

On the basis of need, the following commodity category definitions were applied:

1. Industrial Minerals of National Importance. These are minerals for which a significant fraction of national supply is provided by California or which might be critical under the conditions of an uncertain foreign supply. They are defined to include asbestos, special clays, high quality silica, talc, wollastonite and zeolites. Although barite and fluorspar should be included in this group, they were judged unclassifiable by the methodology employed and were omitted.

2. Industrial Minerals of Regional or Statewide Importance. These are minerals which have economic value, essentially insensitive to location, but which are not considered to be critical. They are defined to include abrasives, diatomite, feldspar, gemstones, kyanite-sillimanite-andalusite group, limestone and dolomite, magnesite, mica, perlite, pumice, pyrophyllite, speciality sands and sulfur.

3. Construction Materials. These are low value minerals used primarily for construction and decoration. A large part of the cost of supply of these minerals is transportation. They are defined to include common clays, decorative stone, dimension stone, expansible shales, roofing granules, sand and gravel, and volcanic cinders. This group of mineral materials was judged not to be amenable to resource classification mapping because the materials are either so common and widespread or such a very broad spectrum of rock materials can be adapted for their use that virtually all areas would be favorable for one or more of the group. Furthermore, some of the group are so strongly dependent upon proximity to marketing areas, that their geographic location is as important to development as are their physical specifications. Sand and gravel deposits, for example, are worked along highways and near communities, or, in the case of the Imperial Valley, where installation of drains in farmland required large quantities of sand and gravel. Therefore, one member of the committee, Ward Smith, prepared a sand and gravel map which shows all reported sand and gravel pits and their relationship to roadways.

Maps of the northern half of the CDCA were prepared by Charles Park, Ward Smith and Gordon Oakeshott (who also mapped the southern portion), using the following method:

1. All known occurrences were plotted based on TERRADATA's occurrence maps. Occurrence overlays were placed over the Geologic Map of California.

2. On the basis of the maps showing location of occurrences, plus the panelists' knowledge and professional judgments, areas were assigned to one of the following categories for critical or regionally important minerals:

   a. Available information based upon prospecting or mining activity indicates that the resource is present.

   b. Available geologic information indicates the resource is present, but its useability has not been proven by mining activity or prospecting.

   c. Existing information indicates the area is unfavorable for resource occurrence or data for the area are insufficient for classification.

Maps of the southern half of the CDCA were prepared by Paul Morton, Cliffton Gray and James Davis, using the following method:

1. All known occurrences within a commodity group were plotted on mylar overlays.

2. The overlays were placed over the State Geologic Map Sheet and relationships between the geology and resource commodities were studied.

3. A matrix was prepared for each lithologic map unit on the State Geologic Map Sheet within the CDCA showing its classification category (1, 2, 3 or 4, see below) for each commodity within a particular commodity group (critical, regional). The category assigned was the highest favorability rank occurring in any of the commodities considered (i.e., if one commodity was Category 1 and all others were 3, 1 was assigned).

4. Map units were then grouped into the four classification categories and outlined as appropriate on the overlays.

5. The process was repeated for each $1^{o} \times 2^{o}$ map sheet taking into consideration regional variations and occurrence parameters for each.

The classification categories were:

Classification Categories	Criteria
1. Available information indicates resource group is present or is very likely to be present.	This category was used very critically. Only essentially demonstrated, known areas were assigned, based upon the inventory data supplied, limited literature search and personal knowledge of the compiler. Where a particular lithologic unit is of demonstrated favorability, areas underlaid by it were included but not beyond the region of known geologic controls.
2. Available information indicates resource group could be present.	This category was used in a very broad sense. It includes any reasonably well-known geologic environments that could have resulted in formation of economic mineral deposits. The geologic favorability for occurrence of economic mineral deposits is classed as hypothetical and speculative.

3.	Available information indicates resource group is unlikely to be present.	This category was used where reasonably well-known geologic environments are unfavorable for the occurrence of economic mineral deposits of the stated resource group. Alluviated areas in this category are so classified strictly on the basis of occurrence of the alluvial unit; no judgment concerning buried deposits was made unless positive subsurface data were known.
4.	Available information is insufficient to form a valid conclusion.	This category was used where the available data or time constraints did not allow for supportable classification in the other categories.

Although there were differences between the methodology and approaches used in sampling the northern and southern portions of the CDCA, the results were judged by the committee to be compatible. The significance of Categories 1 and 2 is the same on both the northern and southern sheets. The committee as a group analyzed the maps of the entire area and developed a consensus on distributions of Category 1 and 2 areas. Category 3 in the northern sheet includes both areas of unfavorable resource potential and areas where insufficient information exists to warrant further classification. These two types of circumstances are separately delineated as Categories 3 and 4, respectively, in the southern sheet.

The committee agreed that BLM should consider the requirements for construction materials when designating areas for future growth. These would include highways, utility corridors, urban areas and areas of industrial or energy production growth.

Charles Park Comments:

It has been said that any large body of a single mineral—limestone, talc, clay, etc.—may be useful, depending upon its location. A large economic factor is salesmanship. As population spreads from the urban centers, construction materials become increasingly needed. Sand and gravel may be recovered from many places, preferably close to roads. Such materials are important, but locations of future deposits cannot be predicted with certainty. Any such prediction will surely be out of date in very few years.

The great diversity of commodities in the industrial minerals fields makes classification difficult. Deposits of some minerals such as talc and fluorite are of considerable national and international interest. To include these materials in the same category as gypsum or ordinary brick clay is patently impractical.

The great amount of available data, some good and some not so good, has been extremely difficult to digest properly in the time available. The broad personal knowledge of the panel in many areas has helped to sort good from the bad. The map should prove useful, keeping in mind that it is based on present knowledge and that the minerals industry is always changing. It is not static and presently uneconomic deposits may become valuable if technology changes or economic conditions improve.

James Davis, Cliffton Gray, Paul Morton Comments:

The maps as prepared by the industrial minerals committee represent what should be considered to be a rough first draft. The data upon which the classification was completed were primarily on the industrial minerals plot provided by the BLM. CDMG reports were utilized but not in a uniform or complete way; hence, literature search and input is incomplete. The various 1° x 2° sheets were constructed by various participants and reflect variations in professional judgments and are, consequently, in need of uniformity adjustments. This is particularly true between the northern half and southern half which CDMG prepared. In order for these maps to have professional credibility, it is necessary to be certain that all parts of the maps are uniform in approach and therefore in reliabilty. Further work could provide more assurance of internal consistency.

It is evident in the abundance of the unit 4 (insufficient data upon which to classify) that the data base available for the preparation of such maps is grossly deficient. This is, to a large extent, the result of limited data sources, rather than a result of the short time available for developing these maps. This limitation should be taken into account by BLM planners who should work with the understanding that the extent of resource distribution is greater than our current knowledge of its existence. By the same token, the amount of area occupied by Category 2 as compared with Category 1 reflects the judgment that many areas contain geologic environments that are favorable for exploration even though definite evidence for mineral deposit occurrences are generally lacking. If Category 4 were not used most of such areas would fall into Category 2 rather than 3, because it cannot be judged that the geologic environment precludes the presence of mineral deposits. If the BLM staff chooses to eliminate Category 4 on our maps, it should be combined with Category 2. It is stressed that the relatively few areas in Category 1 are not a reflection of the complete mineral potential of the CDCA.

Ward Smith Comments:

The report for our group summarizes very well the difficult problems with this large mixed bag of commodities. The maps turned out as well as could be expected, considering the problems and the short time available. The members from the State Division of Mines deserve most of the credit for bringing the maps into a usable condition.

Gordon Oakeshott Comments:

General

The following remarks refer principally to the southern half of the Industrial Minerals map; I have no special criticisms of the northern half of the map. The addition of "national" and "regional" significance to the northern half is acceptable.

CDMG is to be credited with a very detailed and careful job; evidently with a large investment of time.

In our briefing, the time element for planning was given as 100 years. This seems to give us latitude to use imagination—tempered by professional judgment—in advising BLM on land classification. Because of the great and fundamental problems and necessity of ensuring adequate mineral resources for the future, it seems reasonable to emphasize Categories 1 and 2 and to enlarge them when at all reasonable. These are the areas which may eventually be classified as mineral lands.

The data sheets compiled by TERRADATA (LANDSAT, gravity, geochemical) are excellent. Evidently, not much use was made of these data; probably because of insufficient time. They would assist materially in thinking of the future.

The future importance and use of the saline and industrial minerals in a given area depends greatly on urban development, plus major highways, railroads, canals, pipelines, military bases, etc. This major fact we have largely failed to develop; of course, we lack much of the data base for such projections.

The uses, and therefore the importance, of certain minerals are constantly changing, thus enhancing the value of some presently uneconomic minerals and some minerals presently unknown. The converse is also true, that some natural minerals are becoming less useful because of changing demands and the development of synthetic and manufactured substitutes or changes in economic sources (just one example: magnesite deposits have little value today because sea water has become the economic source).

Objectives of the study

Land-use planning for mineral resources for the next 100 years is our objective. We understand that BLM will adopt a multiple-use approach, and that our present panel effort is part of a pilot study.

I think that all our panel members recognized these basic points, but still the maps reflect today's situation and are not imaginative enough for the distant future.

CDMG Classification: Critical (national), Regional (State and Local), Construction Materials

The designation "critical" holds strictly for the present situation; it is probably not valid for our consideration of the future. Today's critical mineral commodity is stock-piled by the government and tomorrow the same is sold by the government as excess. What is critical changes very fast. Right now, for instance, artificial "zeolites" seem to be replacing natural zeolites, for economic reasons.

What is critical in wartime may not be critical at other times. Even in "normal" times, what is critical changes fast. Petroleum is now fast becoming critical to the U.S., but how may times has petroleum been surplus—a drug on the market? I can remember when Texas oil sold for $.15 a barrel.

Political climates change daily and greatly influence what we call critical and imported minerals may become in critically short supply at any moment, as political changes occur around the world.

National ideas of critical mineral resources also change with, and because of, our rapidly changing technology. Cheaper (and often better) manufactured, artificial and synthetic mineral substances replace natural sources.

Minerals of "regional" (state and local value) may become national in importance. Certainly, gemstones such as tourmaline and kunzite from Pala, California and jade from California are of national interest. Diatomite and its manufactured products go from California to other parts of the United States and the world.

My conclusion is that the division of mineral commodities into "critical" and "regional" is not necessary or particularly important to our objectives.

Classification Categories

I agree with the definitions under "Classfication categories" but a more liberal and imaginative interpretation of all the categories—with more thought for the future—would be more useful to BLM for land-use planning for the CDMG. Of course, all operating properties would be allowed to continue mining operations under any land-classification plan, but such operations, or others, should be allowed to explore and expand into similar geologic environments.

Category 1: This category has been used in a far too restricted sense. I had trouble finding any Category 1 areas on the CDMG maps.

Category 2 areas seem generally well-chosen and well-delineated on the maps except that parts of them should hve been assigned to Category 1. This is a very useful category.

Category 3 should have been used sparingly. The history of the 20th century is replete with important mineral resource developments in "unfavorable" areas. Around the turn of the century, California was written off by many "authorities" who believed the geologic conditions unfavorable to commercial production of petroleum. How many areas we have classified as Category 3 will be important producers of certain minerals 50 or more years from now?

Some areas marked "3" on the maps are too small to be significant; this is also true of other categories.

Category 4 seems to me to be something of a "cop-out." In relatively few cases do we have all the information we would like to evaluate a given area. Otherwise, there would be little incentive for futher exploration for mineral resources for the future. I think that (by spending more time) we could take Category 4 areas and break them down into Categories 2 and 3.

There has not been sufficient consideration of the distant future—50 to 100 years from now.

For BLM purposes, and duly considering our charge, I still think it would be well to merge Category 4 back into 2 and 3. It is true that Category 4 lets our panel "off the hook" to some extent; we are not forced into a decision when data are scarce or lacking. Otherwise, the only real usefulness of Category 4 is that it may—and should—stimulate CDMG and USGS to do more field work to upgrade what has been done in geology and mineral resources to the point where we could confidently classify such areas.

Construction Materials

I agree with CDMG's statement on the difficulties of resource classification of construction materials, but I still think we must try. It is important that not all desert sources of such vital materials be preempted for other uses.

Contents

EXPERT PANEL CLASSIFICATION MAPS:

CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

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Fenner
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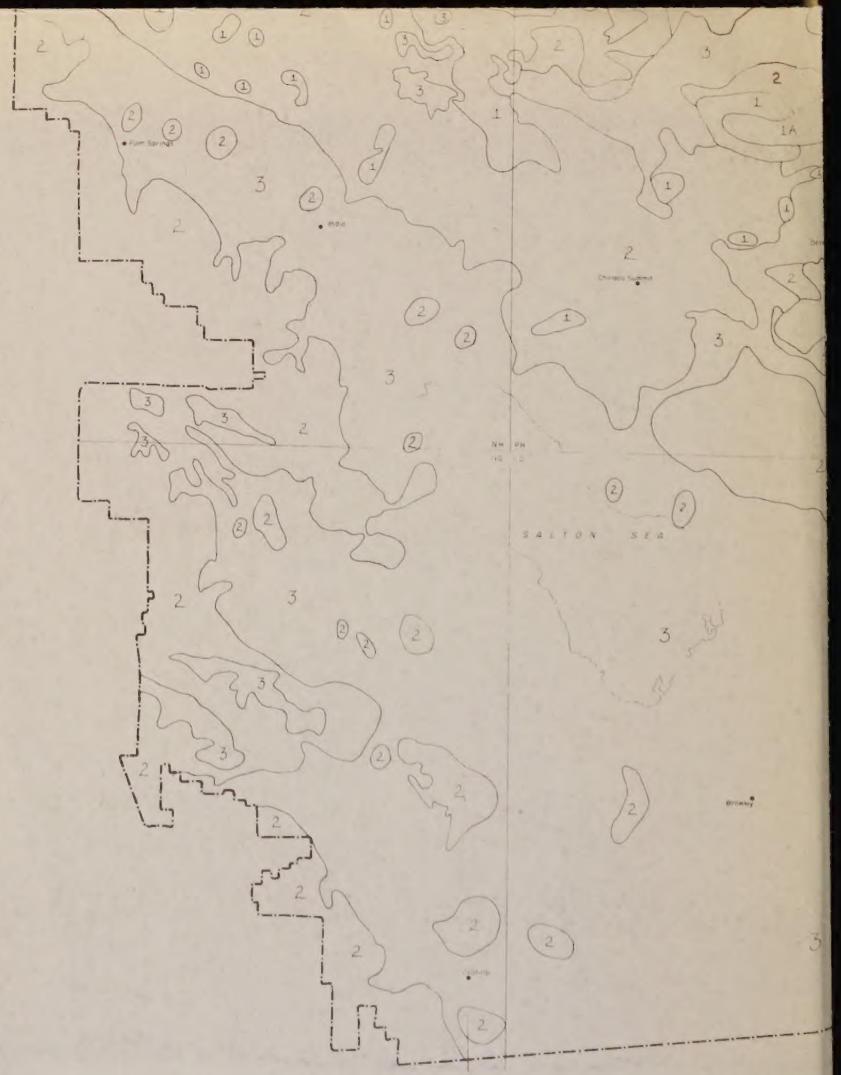
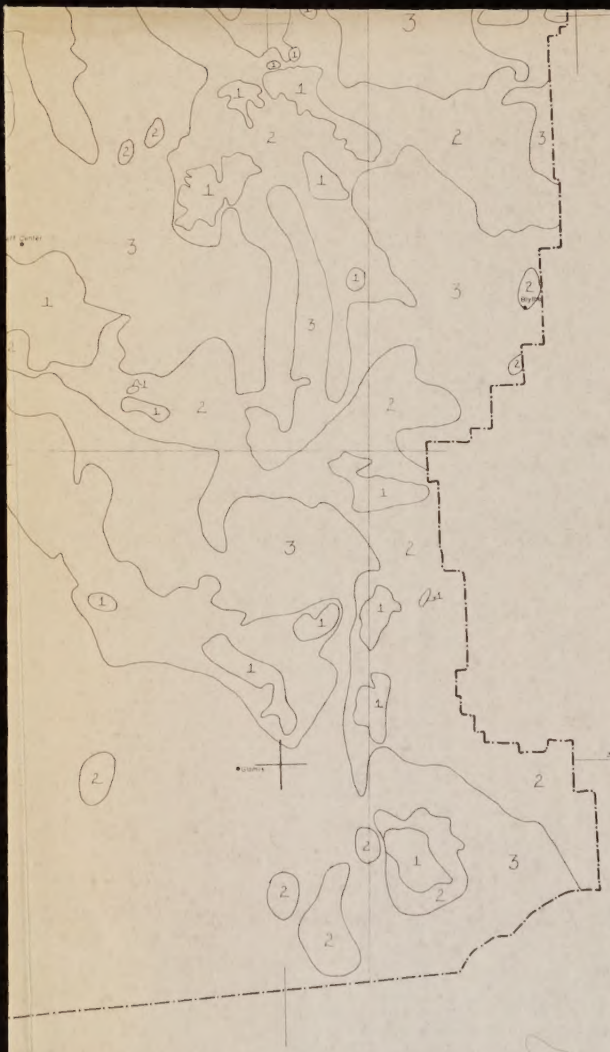
Vidal Junction


SALTON SEA



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Panelists:

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James F. Davis
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Refer to accompanying report for detailed explanations.
Prepared under Bureau of Land Management Contract No. YA-512-CT9-66

CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

NATIONALLY IMPORTANT INDUSTRIAL MINERALS

Classification Categories

North of 35°N Latitude:

1. Resource Present Based on Prospecting or Mining Activity Information.
2. Resource Present Based on Geologic Information.
3. Unfavorable Area or Insufficient Information to Classify.

South of 35°N Latitude:

1. Resource Present or Very Likely to Be Present Based on Available Information.
2. Resource Could Be Present Based on Available Information.
3. Resource Unlikely to Be Present Based on Available Information.
4. Insufficient Information to Form a Valid Conclusion.

Nationally Important Industrial Minerals include: Asbestos, Special Clays, High Quality Silica, Talc, Wollastonite and Zeolites.

Panel Moderator:
John W. Harbaugh

Panelists:

John P. Albers
John T. Awald
Kenneth C. Bullock
James F. Davis
Frederic G. Fleis
Clifford H. Gray, Jr
Paul K. Morton
Gordon B. Oakleafoot
Charles F. Park, Jr
Ward C. Smith

TERRADATA

Frederic W. Lambe, Project Manager
Glen R. Kendall, Project Director
Antonia Stenaitis

BLM Project Officer: Mr. Jean J. Juilland

Refer to accompanying report for detailed explanations.
Prepared under Bureau of Land Management Contract No. YA-512–CTA-68.

CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

NATIONALLY IMPORTANT INDUSTRIAL MINERALS

Classification Categories

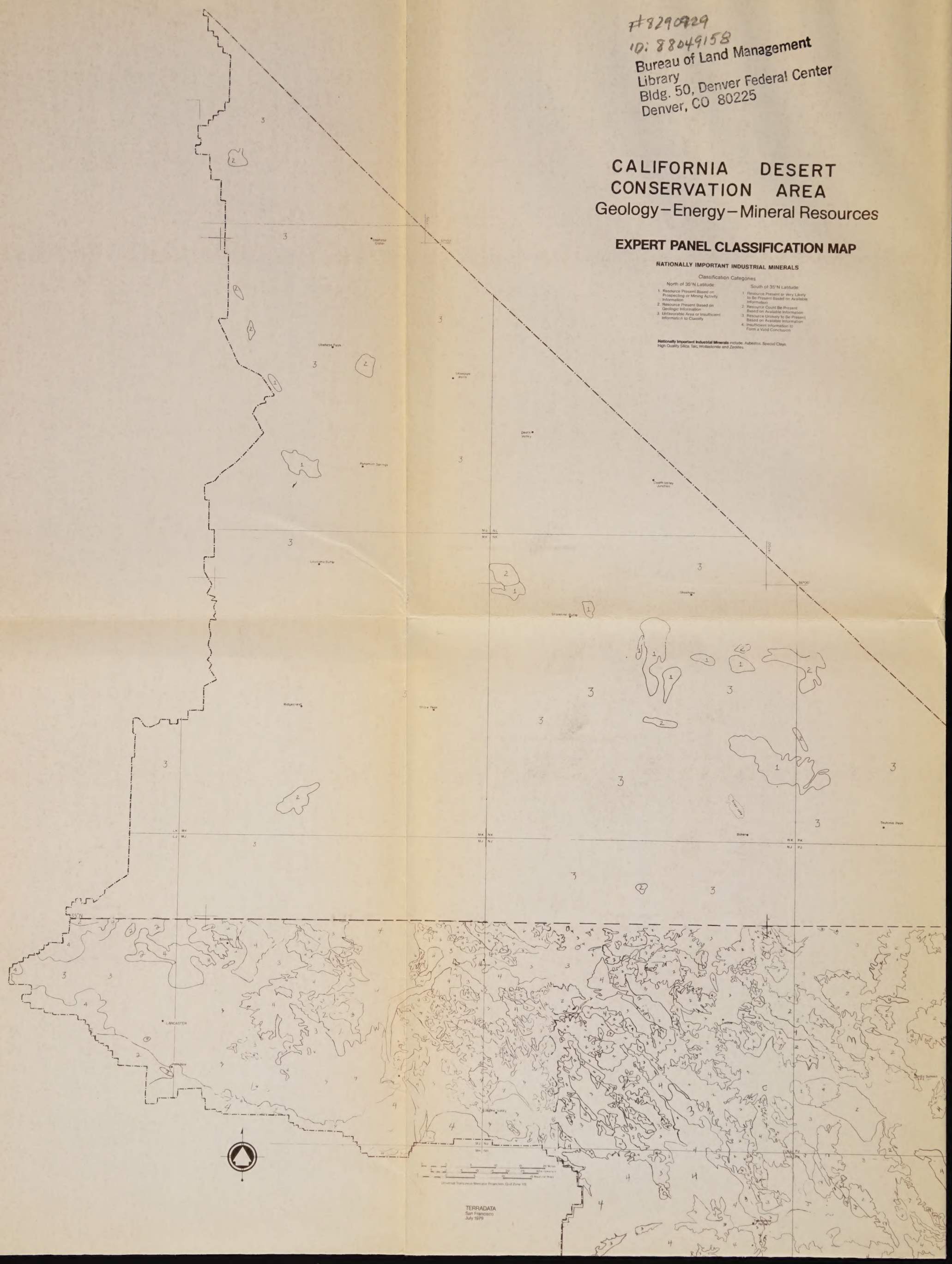
North of 35°N Latitude:

1. Resource Present Based on Prospecting or Mining Activity Information
2. Resource Present Based on Geologic Information
3. Unfavorable Area or Insufficient Information to Classify

South of 35°N Latitude:

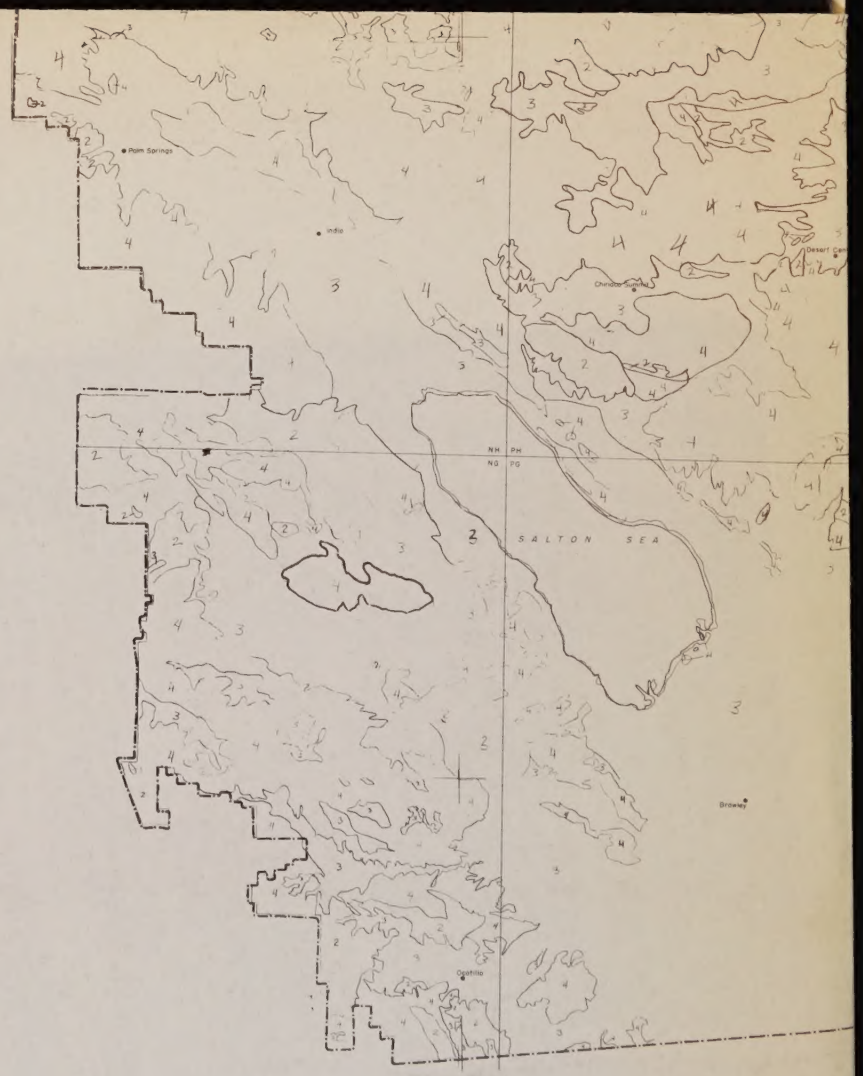
1. Resource Present or Very Likely to Be Present Based on Available Information
2. Resource Could Be Present Based on Available Information
3. Resource Unlikely to Be Present Based on Available Information
4. Insufficient Information to Form a Valid Conclusion

Nationally Important Industrial Minerals include: Asbestos, Special Clays, High Quality Silica, Talc, Wollastonite and Zeolites.



TERRADATA
San Francisco
July 1979

35°00'
35°00'
Bannier
PJ QJ
RH QH
Vidal Junction
Vidal


Palm Springs
Indio
Desert Center
Chiriaco Summit
NH PH
NG PG
SALTON SEA
Brawley
Ocotillo

Panel Moderator:
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Panelists:

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James F. Davis
Frederic G. Files
Clifton H. Gray, Jr
Paul K. Morton
Gordon B. Oakeshott
Charles F. Park, Jr.
Ward C. Smith

TERRADATA

Frederic W. Lambie, *Project Manager*
Glen R. Kendall, *Project Director*
Antonia Stanaitis

BLM Project Officer: Mr Jean J. Juilland

Refer to accompanying report for detailed explanations.
Prepared under Bureau of Land Management Contract No YA-512-CT8-66.

CALIFORNIA DESERT CONSERVATION AREA
Geology–Energy–Mineral Resources

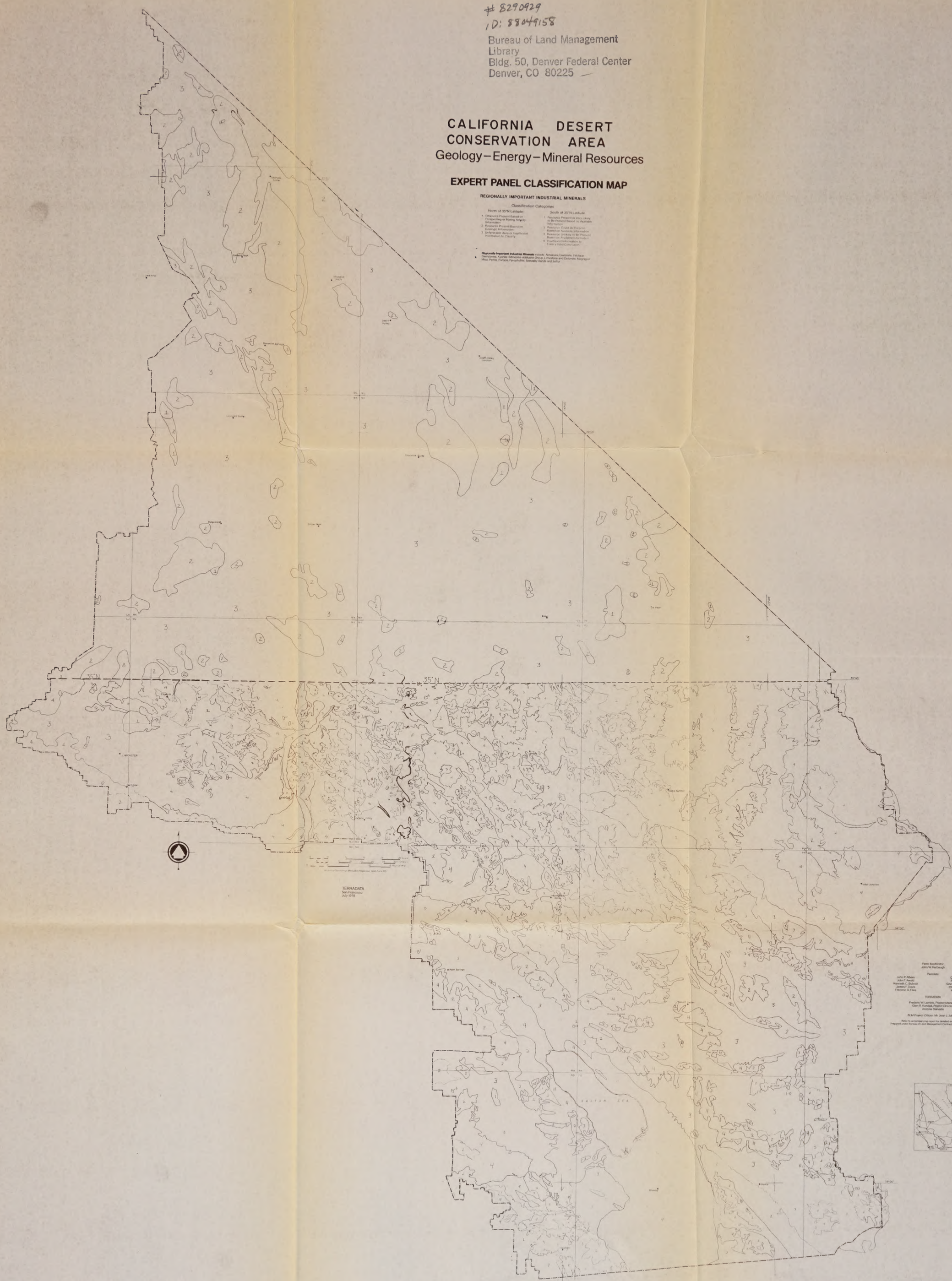
EXPERT PANEL CLASSIFICATION MAP

REGIONALLY IMPORTANT INDUSTRIAL MINERALS

Classification Categories

North of 35°N Latitude	South of 35°N Latitude
1 Resource Present Based on Prospecting or Mining Activity Information	1 Resource Present or Very Likely to Be Present Based on Available Information
2 Resource Present Based on Geologic Information	2 Resource Could Be Present Based on Available Information
3 Unfavorable Area or Insufficient Information to Classify	3 Resource Unlikely to Be Present Based on Available Information
	4 Insufficient Information to Form a Valid Conclusion

Regionally Important Industrial Minerals include: Abrasives, Diatomite, Feldspar, Gemstones, Kyanite-Sillimanite-Andalusite Group, Limestone and Dolomite, Magnesite, Mica, Perlite, Pumice, Pyrophyllite, Specialty Sands and Sulfur



TERRADATA
San Francisco
July 1979

Panel Moderator:
John W. Harbaugh

Panelists:

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John T. Awald	Paul K. Morton
Kenneth C. Bullock	Gordon B. Oakeshott
James F. Davis	Charles F. Park, Jr.
Frederic G. Files	Ward C. Smith

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Glen R. Kendall, Project Director
Antonia Stanaitis

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Refer to accompanying report for detailed explanations.
Prepared under Bureau of Land Management Contract No. YA-512–CT9-66

CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

REGIONALLY IMPORTANT INDUSTRIAL MINERALS

Classification Categories

North of 35°N Latitude:

1. Resource Present Based on Prospecting or Mining Activity Information
2. Resource Present Based on Geologic Information
3. Unfavorable Area or Insufficient Information to Classify

South of 35°N Latitude

1. Resource Present or Very Likely to Be Present Based on Available Information
2. Resource Could Be Present Based on Available Information
3. Resource Unlikely to Be Present Based on Available Information
4. Insufficient Information to Form a Valid Conclusion

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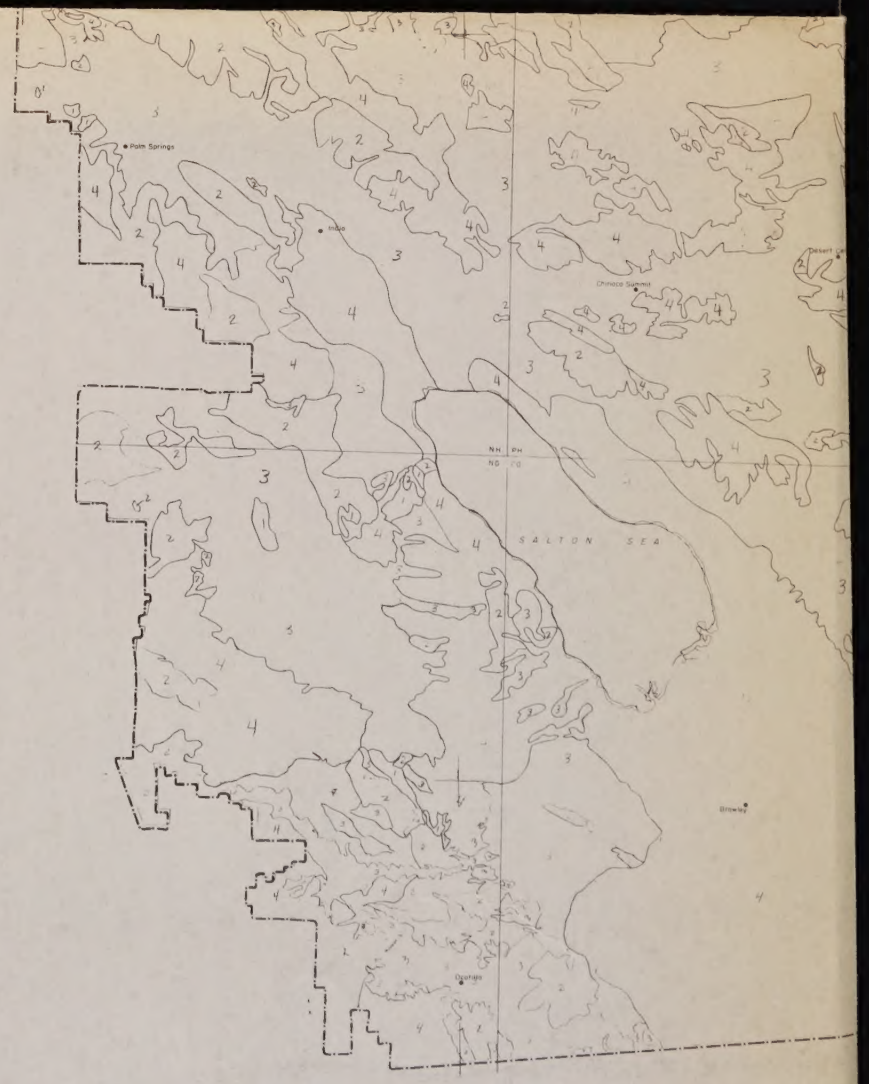
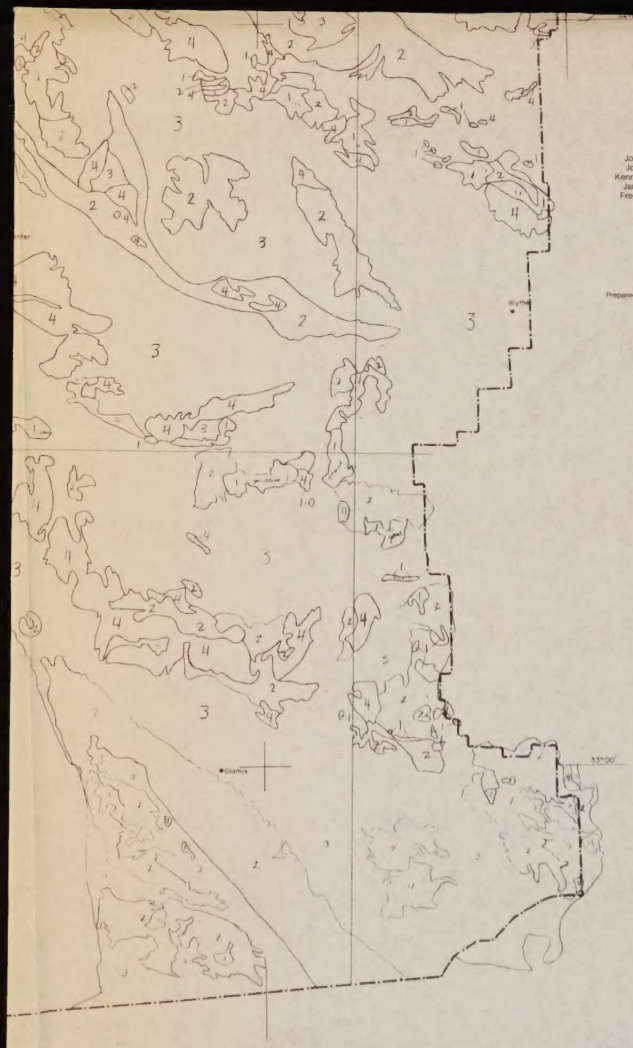
TERRADATA
San Francisco
July 1979

115°00'
35°00'
Fenner
Vidal Junction


Palm Springs
Indio
Chiriaco Summit
Desert Center
SALTON SEA
Brawley
Ocotillo



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CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

CALIFORNIA DESERT CONSERVATION AREA

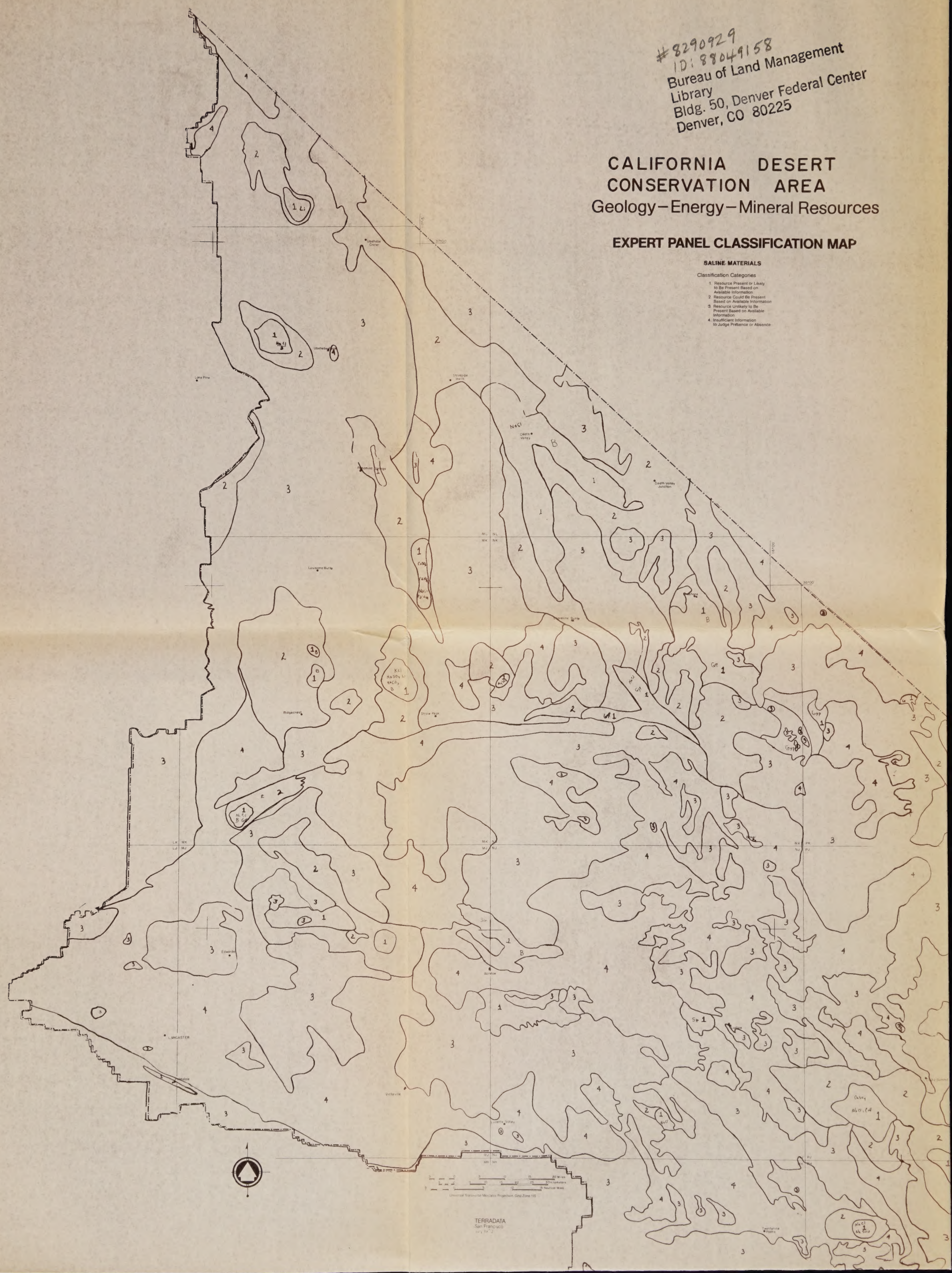
Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

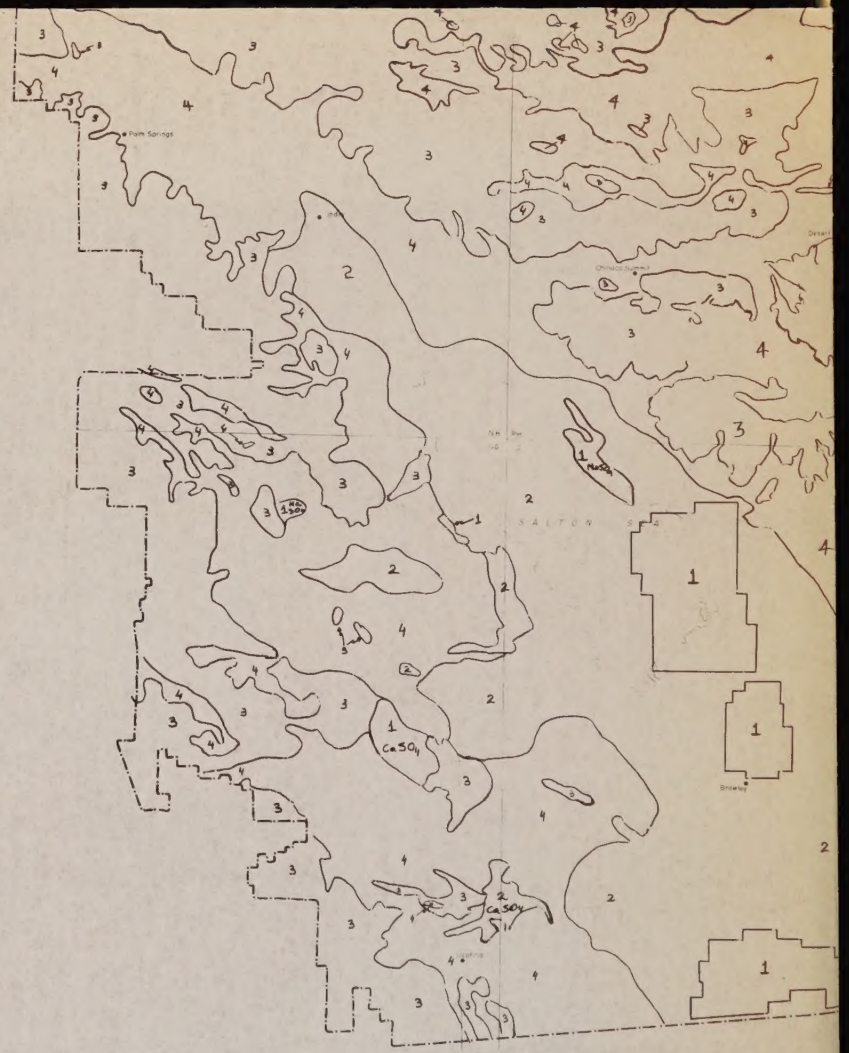
SALINE MATERIALS

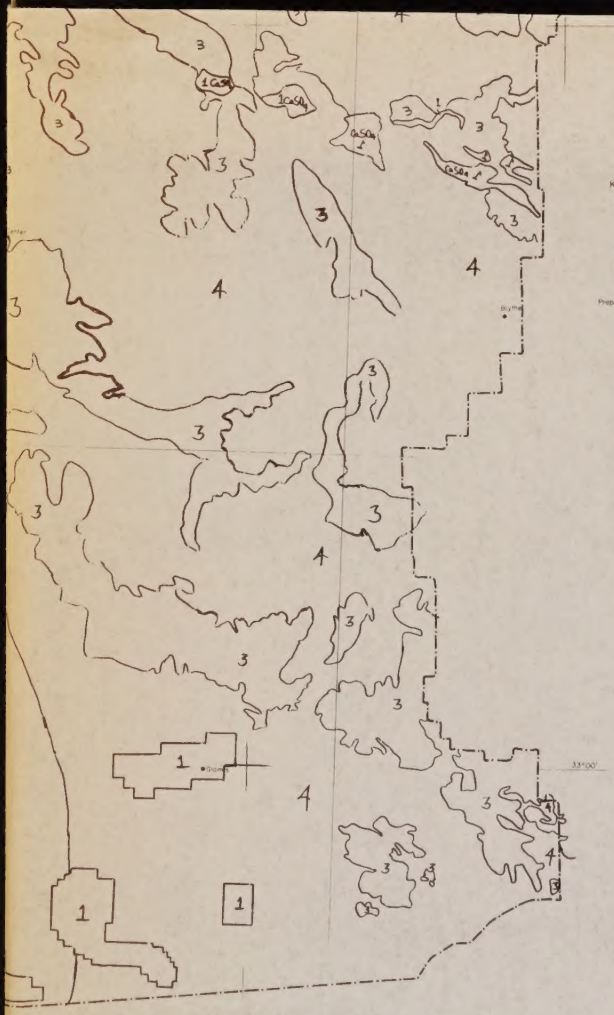
Classification Categories

1. Resource Present or Likely to Be Present Based on Available Information
2. Resource Could Be Present Based on Available Information
3. Resource Unlikely to Be Present Based on Available Information
4. Insufficient Information to Judge Presence or Absence



NaCl
Tanner
Junction
NaCl
CaCl
Ca SO4
KCl
NaCl
Na SO4
Ca SO4


Palm Springs
Chiriaco Summit
Desert
SALTON SEA
Brawley
Niland
Westmorland
Na_2SO_4
$CaSO_4$
$CaSO_4$



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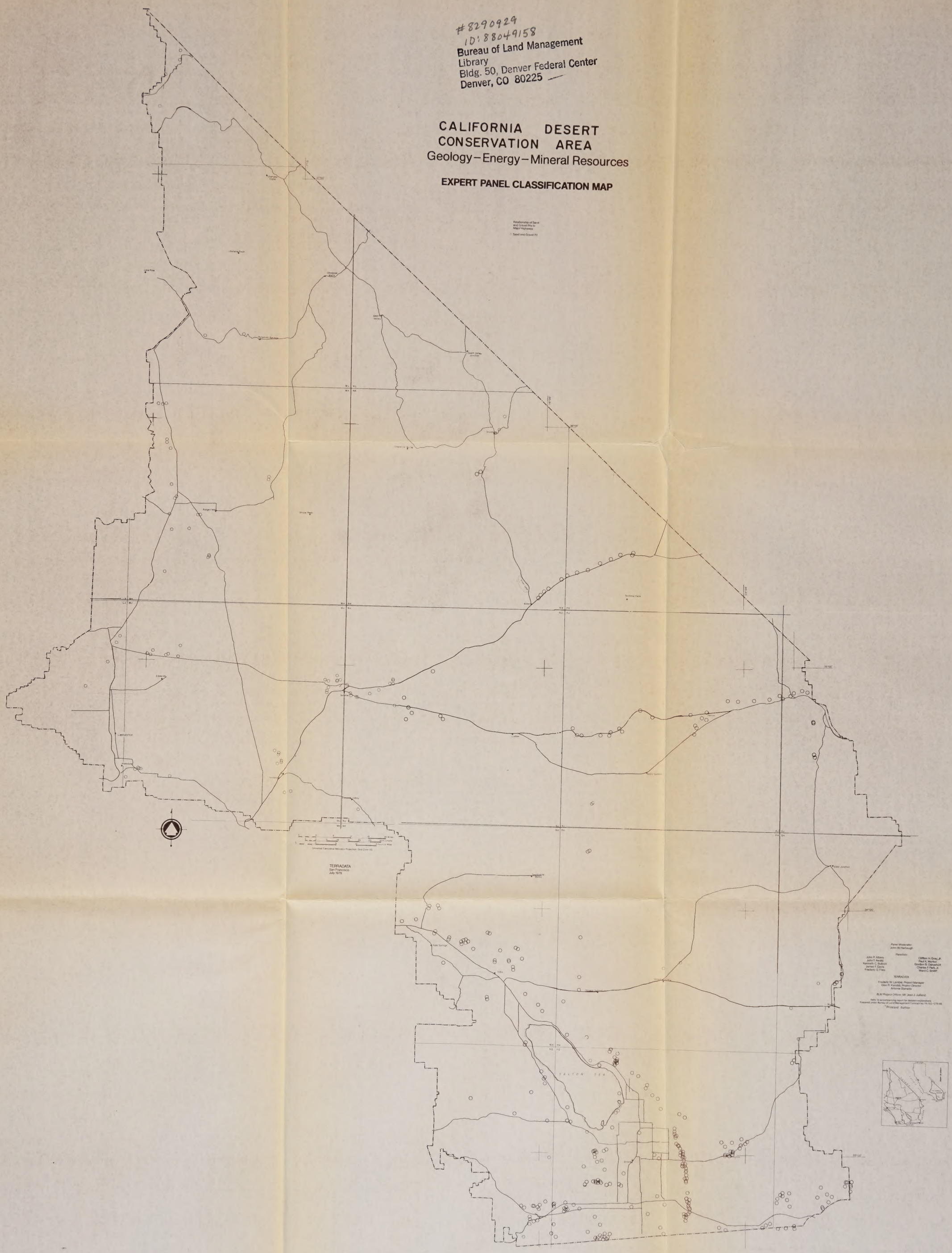
CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

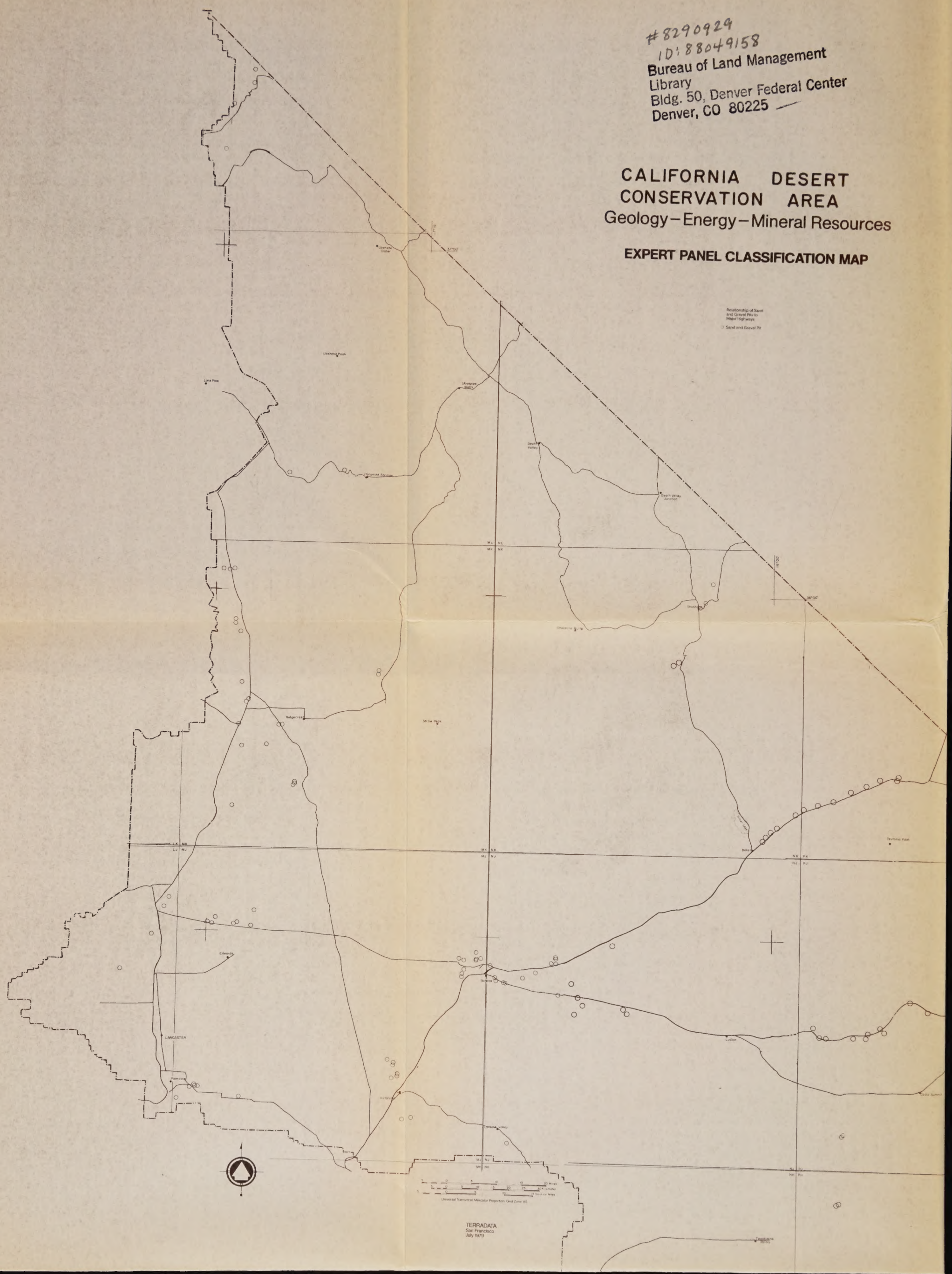
EXPERT PANEL CLASSIFICATION MAP



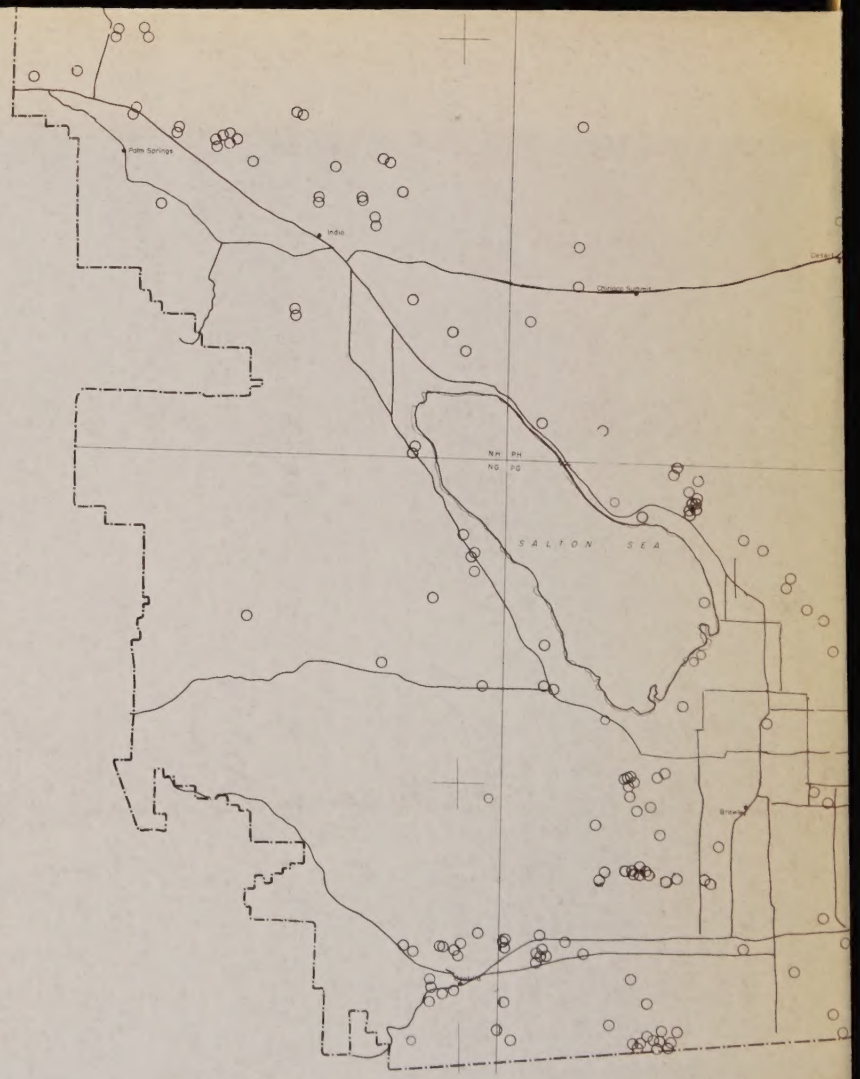
CALIFORNIA DESERT CONSERVATION AREA

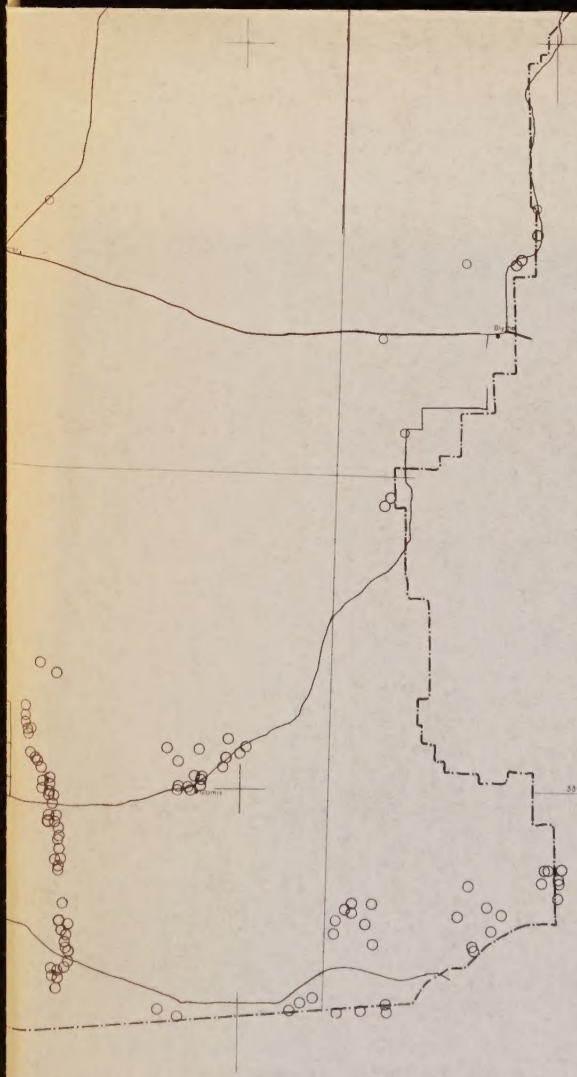
Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP



115°00'
35°00'
Fenner
PJ QJ
PH QH
Vidal Junction


Palm Springs
Indio
Desert
Chiriaco Summit
NM PH
NG FG
SALTON SEA
Brawley



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Gordon B. Oakeshott
Charles F. Park, Jr.
Ward C. Smith*

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Glen R. Kendall, *Project Director*
Antonia Stanaitis

BLM Project Officer: Mr. Jean J. Jutland

Refer to accompanying report for detailed explanations.
Prepared under Bureau of Land Management Contract No. YA-512-CT9-66

*Principal Author

CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

URANIUM

Classification Categories

1. Favorable Area
2. Intermediate Area
3. Unfavorable Area
4. Insufficient Information to Classify Area

Drill Site
5 Mile Radius
Over 20ppb U

Drill Site
5 Mile Radius
Under 20ppb U

Panel Moderator
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Panelists

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Kenneth C. Bullock
James F. Davis
Frederic G. Fries
Clifford H. Gray, Jr.
Paul K. Morton
Gordon B. Oakeshott
Charles F. Park, Jr.
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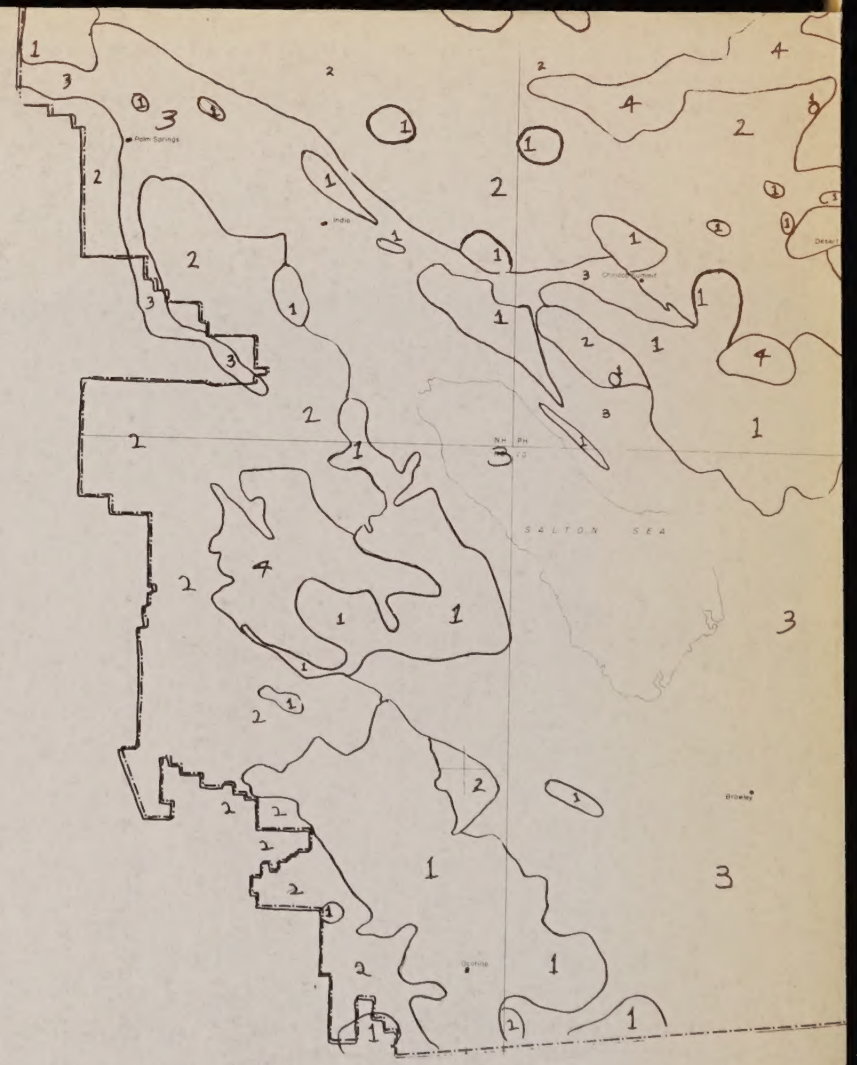
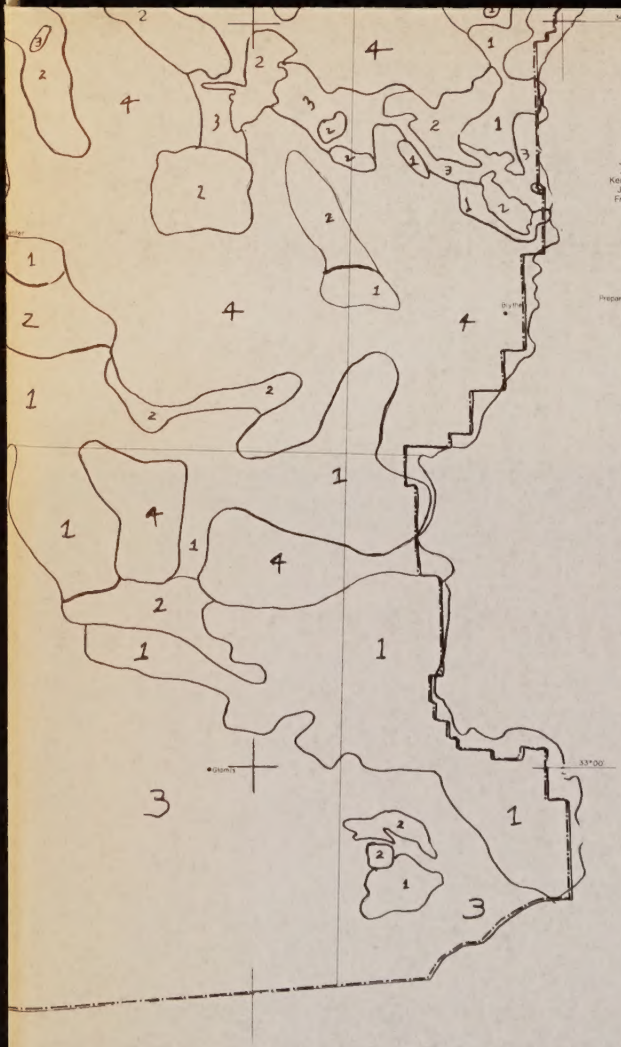
CALIFORNIA DESERT CONSERVATION AREA

Geology–Energy–Mineral Resources

EXPERT PANEL CLASSIFICATION MAP

15°00'
35°00'
Vidal Junction


Palm Springs
India
Desert
SALTON SEA
Brawley
Ocotillo



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Appendix A

BRIEF BIOGRAPHY
OF PANELISTS

Dr. John P. Albers is Research Geologist with the U.S. Geological Survey, Western Mineral Resources Branch. He received his B.A. from Carleton College, his M.S. from the University of Minnesota, and his Ph.D. from Stanford University. He has served the Geological Survey for 27 years, including 3 years as Associate Chief Geologist in Washington, D.C. Dr. Albers specializes in economic geology, geologic mapping and tectonic studies. He has conducted major projects of the Metaline lead-zinc district, Washington; the Shasta copper district, California; Esmeralda County, Nevada; and the Josephine ultramafic body and chormite body in Del Norte, California. He is a former advisor on economic geology to the Director of the Geological Survey of India; Executive Secretary of the President's Commission on Marine Science, Engineering and Resources; advisor to the Director of Mineral Research and Exploration, Institute of Turkey; and advisor to the U.S. Delegate to the U.N. Law of the Sea Conference.

Dr. John T. Awald is President of Systems Exploration, Inc. He received his B.S. in geology from the University of Kansas and his Ph.D. in geology from Stanford University. He is an expert in geochemical sampling, design, techniques, analysis and evaluation. His current work emphasizes a systems approach to mineral exploration. Dr. Awald was a geologist with the Atomic Energy Commission and with Union Carbide Nuclear Company where he was involved with Uranium exploration in the Colorado Plateau. Later he was Group Leader of exploration research development and mine evaluation for Union Carbide Mining and Metals. As Research Geologist for AMAX Exploration, Inc., he applied operations research theories to increase the efficiency of exploration. More recently he was Vice President of Exploration for Denver Mineral Exploration. Dr. Awald has consulted on mineral exploration to several mining companies including EXXON, Union Pacific and Callahan Mining.

Dr. Kenneth C. Bullock is Professor of Geology at Brigham Young University. He has taught geology at Brigham Young University for 26 years and was Chairman of the Department of Geology for 6 years. He received his B.S. and M.A. Degrees in geology from Brigham Young and his Ph.D. in geology from the University of Wisconsin. Dr. Bullock is an expert in ore deposits (especially iron ore) and economic geology. He has evaluated deposits of iron, manganese, flourite, copper, molybdenum, lead, zinc, uranium, tungsten, gypsum, limestone and clay. He has consulted for numerous government and industrial clients including the U.S. Bureau of Mines; the Utah Geological and Mineral Survey; U.S. Steel; Columbia Iron Mining Co.; Geneva Steel Co.; Interstate Brick Co.; and U.S. Mining, Smelting and Refining Co. He is author of the text, Uranium, Where It Is and How to Find It. Dr. Bullock was a member of the International Field Institute in Brazil, is a member of the Mineral Resource Committee for Central Utah and is a Council Member of the Utah Geological and Mineral Survey.

Dr. James F. Davis is State Geologist and Chief of the California Division of Mines and Geology. He received his B.A. degree in geology from the University of Virginia and his M.S. and Ph.D. degrees in geology from the University of Wisconsin. He has worked in Idaho, Montana, Alaska, and northern Canada. From 1968 until his current appointment, Dr. Davis was the State Geologist and Chief Scientist of the New York State Geological Survey. During this time, Dr. Davis directed major projects in seismology, regional geology and geophysics, mineral commodities and environmental and economic geology. He developed the geologic and seismologic criteria for power plant siting in the state of New York and was a major participant in the 1976 Nuclear Regulatory Commission appeal hearings on the seismic safety of the Indian Point nuclear plant site. He directed a study, sponsored by the U.S. Environmental Protection Agency, on potential radionuclide migration at a low-level radioactive-waste disposal site in West Valley, New York. He has also directed a National Science Foundation study on improving the communication of natural resources information to land use decision makers in county and city governments. Dr. Davis has served on a national advisory committee to the Department of Energy on high level radioactive waste disposal and is a consultant to the President's Science Advisory to assist in the design of national earthquake hazard mitigation programs.

Dr. Frederic G. Files is Regional Geologist in charge of the Reno Field Office for the National Uranium Resource Evaluation Program of the U.S. Department of Energy. He received his B.A. and M.S. in geology from the University of Colorado and his Ph.D. in geology from the University of California, Berkeley. He worked for Ausminda Pty., Ltd. in their Australian base metals exploration program, performing surface and underground mapping and geochemical evaluations. He also worked for the Kennecott Explorations (Australia) Pty., Ltd. as a Geologist and later Chief Site Geologist for the reconnaissance of more than 2000 square miles of Prospect Authority around the Mount Fubilan pophyry copper deposit. Dr. Files' principal area of expertise is uranium deposits of the western United States. He has done field work on uranium deposits in Colorado, Wyoming, New Mexico, Texas, Utah, Nevada and California and has developed theories on the deposition of Uranium. Among his publications are "Alteration Associated with Some Wyoming Uranium Deposits (Roll-Type)" and "Uranium in Volcanic Environments in the Great Basin."

Cliffton H. Gray, Jr. is District Geologist of the Los Angeles District Office, California Division of Mines and Geology. He supervises a staff of professional geologists engaged in geology, mineral resource, engineering and environmental geology studies including the evaluation of earthquake hazards. He received his B.A. in geology from UCLA and his M.A. in geology from Claremont Graduate School (Pomona College). As a geologist with the Mineral Deposits Branch of the U.S. Geological Survey he worked on the Mojave Desert and the Florida Phosphate Uranium Projects. With the California Divison of Mines and Geology he has worked on county mineral resource and mineral commodity studies, prepared local and regional geologic maps and directed geologic field investigations in response to several earthquakes. Mr. Gray was Principal Investigator of a USGS grant to study faulting in Southern California.

Dr. John W. Harbaugh, the panel moderator, is Associate Chief Scientist at TERRADATA. He is Professor of Geology and Applied Earth Sciences, and former Chairman of the Department of Geology at Stanford University. Dr. Harbaugh specializes in geostatistical applications, risk analysis and probabilistic decision making for mineral and energy exploration and production. He has consulted for a number of oil companies including Humble Oil and Refining, Exxon Production Research Company and Carter Oil Company. He has also consulted for the national oil companies or petroleum ministeries of the governments of Bolivia, Brazil, and Mexico. Dr. Harbaugh worked with the U.S. Geological Survey on biogeochemical prospecting for uranium. He is principal author of Computer Simulation in Geology and Computer Applications in Stratigraphic Analysis. He is co-author of the book Probability Methods in Oil Exploration and has helped develop a short course on the same subject for the petroleum industry. Dr. Harbaugh has done extensive work on the development of dynamic computer simulation models, and in quantitative exploration decision making methodology. He serves as advisor to the U.S. Bureau of Land Management on regional resource appraisal in the California Desert Conservation Area; to the U.S. Office of Minerals Policy and Research Analysis in matters regarding resource appraisal and exploration planning for the National Petroleum Reserve in Alaska; and the Department of Energy in matters relating to offshore exploration. He has served as Chairman of the Supply-Technical Advisory Task Force, Nonconventional Natural Gas Resources, for the Federal Energy Regulatory Commission.

Paul K. Morton is Senior Geologist and Mineral Officer for the California Division of Mines and Geology. He has been with the Division for 22 years. He received his B.A. in geology from UCLA. Much of his work has been in the California Desert where he has conducted mineral resource inventories, prepared local and regional geologic maps and prepared county reports. Among his reports are Geology of the Queen of Sheba Mine and Limestone Deposits of Imperial County. He is also the co-author of Mines and Mineral Resources of Kern County and author of Geology and Mineral Resources of Imperial County. He is Supervisor in charge of the National Uranium Resource Evaluation for the Trona quadrangle and former Supervisor and Director of the Orange County Cooperative Geological and Environmental Program. As Minerals Officer for the Division, Mr. Morton is responsible for minerals policy and reports, project planning and land classification including the planning and coordinating of projects in the Division's Minerals for the Future Program and the classifying of lands under the Surface Mine and Reclamation Act.

Dr. Gordan B. Oakeshott is a Consulting Geologist and former State Geologist and Chief of the California Division of Mines and Geology. He received his B.S. in economic geology and M.S. in geology from the University of California, Berkeley, and his Ph.D. in geology from the University of Southern California. He served with the California Division of Mines and Geology for 25 years. He was responsible for field work, research, compilations and publications on mineral resources and basic geology. He has conducted field studies in California, Nevada, Oregon and Alaska. Dr. Oakeshott is the author of over 80 publications, several of book length, including a geology of California, California's Changing Landscapes: A Guide to the Geology of the State. Twelve of these publications deal especially with the geologic occurrence, mines, and economics of a wide range of mineral commodities, especially petroleum, natural gas, alumina from anorthosite, diatomite, graphite, iron and titanium. He has also consulted on geothermal resources and earthquake hazards. He has been an instructor of geology at Compton College, State University at Sacramento, State University at San Francisco and at University of California, Berkeley. Dr. Oakeshott is a fellow or member of numerous professional and scientific societies, including Association of Engineering Geologists (Past Chairman of the Sacramento and San Francisco sections), Geological Society of America (Fellow and past Chairman of Cordilleran Section), National Association of Geology Teachers (Past National President), Society of Mining Engineers (Honorary member of Pacific Section), the Explorers Club, California Academy of Sciences, and Phi Beta Kappa.

Dr. Charles F. Park, Jr. Professor of Geology Emeritus at Stanford University. He has taught geology at Stanford for 33 years and was Dean of the School of Earth Sciences for 16 years. He received his B.S. in Mining Engineering from New Mexico School of Mines, his M.S. in Geological Engineering from the University of Arizona and his Ph.D. in Geology from the University of Minnesota. He holds an Honorary D.Sc. from the New Mexico Institute of Mining and Technology and has been presented the Outstanding Achievement Award by the University of Minnesota Alumni. Dr. Park is an expert on ore deposits throughout the United States and the world including much of central and western Europe, Africa, South America, the Far East and Australia. Among his more than 75 publications, he has written the book, with R.A. MacDiarmid, Ore Deposits. He spent 16 years as a geologist with the U.S. Geological Survey, Section of Metalliferous Deposits, and has served as a consultant on ore deposits to a number of companies. Dr. Park is Senior Member of the American Mineralogical Society, a former Councilman with the Geological Society of America and former President of both the Society of Economic Geologists and the International Association on Genesis of Ore Deposits.

Dr. Ward C. Smith is Instructor of geology at Stanford University. He received his B.A. in geology at Stanford and his M.S. and Ph.D. in geology at Yale University. He was a Geologist with the U.S. Geological Survey for 33 years. Much of his field experience is in the California Desert, Nevada and Mexico, where he has prepared geologic maps and conducted mineral resource inventories. He has over 50 publications, including reports of Borates, Tungsten and Tin deposits done for the Geological Survey. In addition, Dr. Smith has taught geology at several institutions, including Pomona College, Yale University and Stanford.